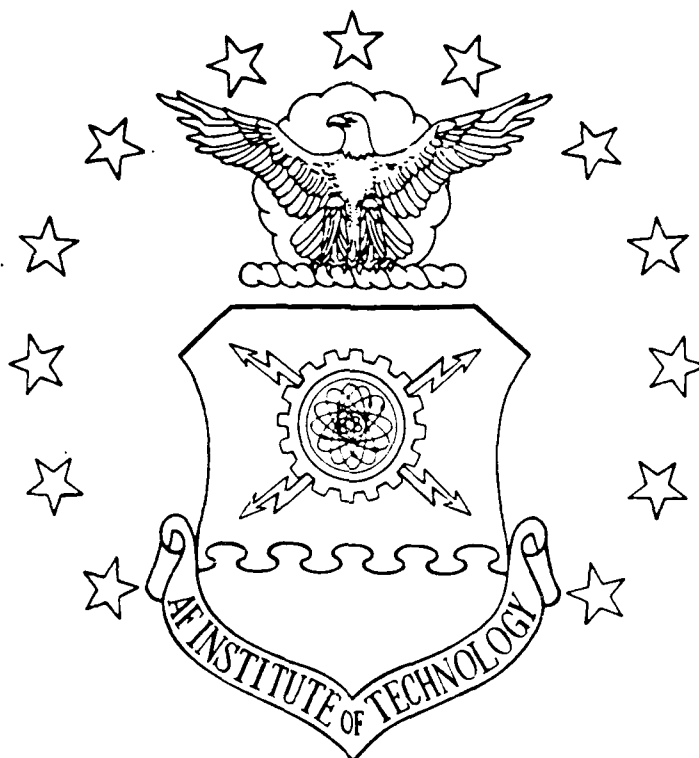AD-A201 488

TECHNOLOGY ASSESSMENT AND
IMPLEMENTATION OF A PROTOTYPE
INTEGRATED GRAPHICS SYSTEM FOR
U.S. AIR FORCE BASE LEVEL
CIVIL ENGINEERING

THESIS

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CIVIL ENGINEERING

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Alfred C. Scharff

Captain, USAF

September 1988

Acknowledgements

I would like to express my appreciation to the people at Wang Laboratories and Intergraph Corporation for lending their time and resources to this research effort.

I would also like to thank Captain Dave Alley, my advisor, for his technical expertise, enthusiasm and positive encouragement throughout this project.

And finally, a special thank you to my wife, Cheryl, for her patience and encouragement.

<div align="right">Alfred C. Scharff</div>

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Abstract

Air Force Civil Engineering, for most of this decade, has been engaged in validating the applicability of CADD and other graphic applications for its use. The Air Force Engineering and Services Center Information Systems Directorate (AFESC/SI) has conducted system development and limited prototype testing through a contract with Oak Ridge National Laboratory (ORNL).

This thesis has made three basic determinations. First, the literature review served to validate ORNL's conclusion that microcomputers still provide the highest performance-to-cost ratio. Because technology is changing so rapidly, this needs to be continually revalidated.

Secondly, this thesis answered some of the basic technical questions about hardware-software and multi-vendor compatibility and data interchange that needed to be answered before AFESC/SI could proceed with IGS procurement.

Finally, this thesis demonstrated the ESIMS concept of IGS which goes beyond automating drafting and design by using such features as a database interface and macro programming language to provide a flexible and multi-functional graphic tool.

TECHNOLOGY ASSESSMENT AND IMPLEMENTATION OF A PROTOTYPE INTEGRATED GRAPHICS SYSTEM FOR U.S. AIR FORCE BASE LEVEL CIVIL ENGINEERING

I. Introduction

Overview

Air Force Engineering and Services (HQ USAF/LEE) formed the Engineering and Services Information Management System (ESIMS) to guide the direction of all automation applications in Engineering and Services. HQ USAF/LEE recognized the potential of computer systems and directed the Air Force Engineering and Services Center Information Systems Directorate (AFESC/SI) to develop and implement computer systems for Engineering and Services worldwide (27:4).

The original implementation plan consisted of three basic phases, the Work Information Management System (WIMS), the Services Information Management System (SIMS) and the Integrated Graphics System (IGS) (Figure 1.1). WIMS and SIMS, both minicomputer based office automation systems, have been developed and are currently being implemented at 135 bases worldwide (11:18). The IGS phase dropped out of the budget because of fiscal constraints. This budget cut has forced Air Force Engineering to examine less expensive options.
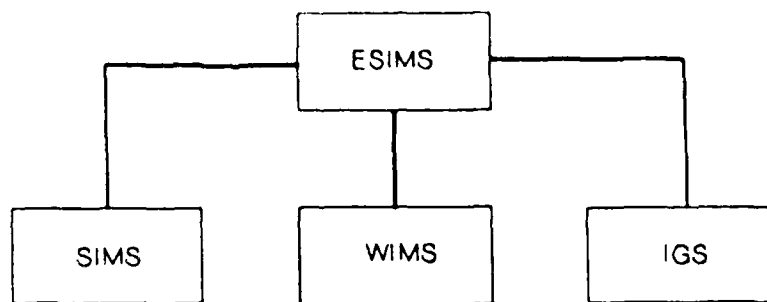
Figure 1.1. ESIMS Concept

IGS Defined

The ESIMS concept, of wh'ch IGS is part, is to have all
Air Force Civil Engineering's management information
systems fully integrated, not only on base but also between
bases, to facilitate the sharing of information. The
following is an overview of the goals and objectives of IGS
and how it fits into the ESIMS concept.

IGS has two objectives. First is to ' provide an
effective and flexible graphic system that will integrate
existing and future data bases ' (7:2) and second to
provide a ' powerful tool to acquire and manage graphic and
attribute data, prepared by both Air Force staff and A-E
contractors, that will increase productivity ' (7:2).

IGS is an interactive system which supports four
basic applications. It will provide Computer Aided Design
and Drafting (CADD), Automated Mapping/Facilities
Management (AM), Facility Management (FM), Geographic
Information System (GIS) (8:2). The following describes
those applications as they are defined in HQ USAF/LEE's
latest guidance letter (8:2).

Computer-Aided Design and Drafting (CADD) has the largest range of applications in the graphics area. The main uses of CADD will be architectural-engineering design and automated drafting of those designs.

Automated Mapping/Facilities Management (AM/FM) will deal primarily with maintaining base utilities. A data base interface with digitized base maps will provide the capability to track material type, installation date, location, capacity and size of utility systems. Reports and other management information can also be generated from the data base.

Facility Management (FM) deals with coordinating the people and work of an organization into a physical workplace. This involves architecture, space planning, interior design, acoustics, lighting, furniture layout and communications and furniture management.

The Geographic Information System (GIS) handles geographically-referenced information used to manage the resource management components of the Base Comprehensive Plan (8:3).

One of the initiatives of ESIMS is a single terminal concept (8:1). The single terminal concept puts forth the idea that each engineer or manager should have only one terminal and that terminal should support all ESIMS applications from automated office to IGS applications (1).

Background

In 1982 HQ USAF/LEEV submitted a funding request for #65 million to fund mini-based, turnkey CADD systems (ie Intergraph,Computervision, etc.) for each Air Force installation world wide. Funding was included in the 1982 Program Objective Memorandum (POM) to support this buy (10:3).

A CADD working group was formed in 1985 to discuss overall USAF strategy for acquisition of CADD systems. It became inactive when, in late 1985, the original #65 million from the 1982 POM was cut from the budget (10:3). The working group was re-activated in 1986 and the name was changed to the Integrated Graphics System working group (10:3). The working group was re-activated to provide guidance to bases willing to take the initiative to implement systems with their own money. The availability and great variety of software and hardware will encourage experimentation by individual bases. The working group wants to establish a standard to the extent that it (1) facilitates the interchange of data between bases and so existing data (such as the Base Comprehensive Plan) can be downloaded to the system and (2) to avoid investing in a system only to find it lacks the functionality to do the job. There are significant cost and problems associated with switching CADD systems. The goal of the working group is to provide a unified Air Force approach in developing IGS that

1.4

coincides with the overall ESIMS plan (8:3).

AFESC/SI is conducting system development and prototype testing to provide an affordable system that bases could purchase with their own funds in the near term and is also continuing to pursue the POM for a worldwide buy (8:4).

The type of funding initiative that got ESIMS off the ground with the purchase of the WIMS and SIMS systems will most likely not be repeated in support of IGS. There is no money programmed in any year POM for Air Force wide purchase of IGS. This is not to say that automating Engineering and Services is not still a top priority, but, that funding for IGS will probably have to come from O&M funds and be spent at the discretion of either the Base Civil Engineer at the base level or the DCS of Engineering and Services at the major command level (1).

Another key player involved in the purchase of IGS equipment is the Directorate of Data Automation and Communications Systems (HQ USAF/SC) which is the approving authority for all Air Force purchases of data automation equipment. HQ USAF/SC, under a standard microcomputer contract called Desk Top II, entered into an Air Force wide purchase agreement with Zenith Corporation for the purchase of Z-248 microcomputers (Figure 1.2). During the time this purchase agreement is in effect purchase of any other microcomputer would require a waiver from HQ USAF/SC (1).
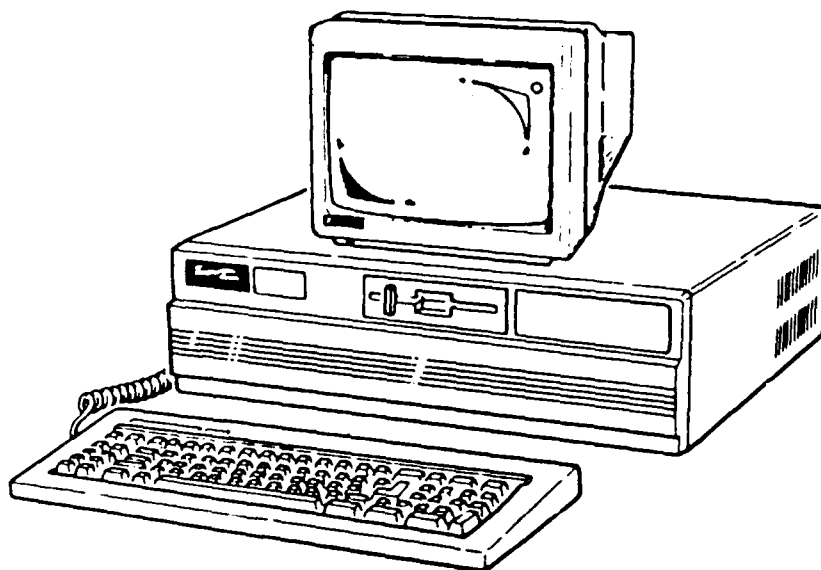
Figure 1.2. Zenith Z-248

As with any mass buy, individual units special requirements are preempted by price advantage. This reality plays particularly hard on IGS because the requirement for a faster machine than the Z-248 can not be satisfied without a waiver. A Request for Proposal has now been issued for a microcomputer with a faster microprocessor under Desk Top III which is a federal government wide buy similiar to Desk Top II (1).

Justification for Study

In an article for The Military Engineer, Elias Tonias states "...the basic reason for automation is to better use one's limited resources to increase productivity, minimize cost, and improve the quality of both service and product" (29:496).

One of the strongest justifications for CADD, is the savings in manhours. CADD will enable Air Force Civil Engineering to accomplish more work at current manning levels. One of the problems in Air Force Civil Engineering is not having enough experienced personnel. A recent study that surveyed the size of Civil Engineering Technical Design Sections discovered that, on the average, there is less than one experienced draftsman for every two design engineers. At the least, this ratio should be reversed (6:5.26).

Shortages in experienced personnel ultimately results in a work backlog. As-built drawing deficiencies are the most often written up deficiency on IG visits. An average Air Force Base has eight to ten thousand as-built drawings on file (27:2). A CADD feasibility study, completed for Wright-Patterson AFB, estimated it would take 313 man years to update the bases as-built drawings manually (28:3-18).

Not having accurate as-built information contributes to inefficiency. An example given in a investigative engineering report, prepared by the San Antonio Real Property Maintenance Agency (SARPMA) at San Antonio, Texas was that, typically, 'Technical Design Sections think nothing of sending three men to the field in a pick-up truck for several days to verify information' (27:23). If our as-built and mapping information was accurate and up-to-date, this field verification would not be necessary

(27:23). Maintenance of as-built and mapping information
is the first step in efficient facilities management,
which is largely the peace time mission of base level
engineering.

The Air Force has experimented with CADD over the last
several years, with some very promising results.
The largest, longest running program the Air Force has is
the CADD system at SARPMA which has been in operation since
1985. The following is a quote from the results of
SARPMA's Phase I production test:

> The total CAD design cost for all projects is $41,150.
> When compared with the total manual cost of design at
> $130,370.88, we find that the CAD test provided
> an average payback of 3.16 to 1. This compares
> favorable with the St. Louis District Corps of
> Engineers CAD test, the result of which varied from 2
> to 1 for architectural work up to 6 to 1 for electrical
> work, with a overall payback average of 4 to 1 over a
> one year period. [11:14]

Aside from the savings realized by reducing in-house
manhours spent on a project, CADD also reduces reliance on
commercial Architects-Engineers (A-Es). CADD potentially
provides a tool to expedite the design process, enabling
the engineering design staff to complete designs faster,
thus accomplishing more projects using in-house labor.
This in turn decreases the bases' reliance and expenditures
on A-E services (11:32).

Current design practice appears to center around
production (i.e. getting the work out) and not around
analysis and synthesis to determine optimal designs

(6:6.4). The consensus among designers is that they need to consider more design alternatives (6:5.17). To offset this problem, automation must be provided to put more output where it counts most today, at the production end (28:2).

CADD provides the facility to reduce errors caused by a lack of coordination and to accommodate changes with far less effort and far better results. In his article in Military Engineering Nicholai Kolesmikoff says:

> ...while the initial loading of project information into the CADD system is as laborious as traditional processes, CADD earns its keep on coordinating various disciplines work and on every change that occurs. Delays and claims often result from design conflicts in building systems. Color overlay techniques allow for simplified cross checking of interference among building systems. CADD's automatic dimensioning capability can reduce the incidence of not updating dimensions when changes are made. [15:487]

Not only does CADD hold potential to relieve designers of some of the tedium of production so they can explore alternative design solutions, CADD is also specifically adept to ˙ what if˙ analysis (27:2.6).

Problem Statement

The automation of the Air Force Engineering needs to take a new direction because of budget constraints. There have been initiatives over the last several years examining CADD systems for Air Force Engineering. However, they have focused almost exclusively on large, expensive minicomputer based systems. While these systems are capable of meeting the need their cost have placed them out of reach for the

average Base Civil Engineer (11:X).

A guidance letter from the Directorate of Air Force Engineering and Services to all major commands, pointed out the need to scale down acquisition in the current budget environment. "Past experience has shown in order to make progress, there must be a willingness to accept basic applications that are not as sophisticated as desired. This will in turn allow us to field a system sooner" (9:1) This guidance is initiating a new look at CADD in the form of smaller more economical microcomputer based systems.

Research Objective

The objective of this work effort is to assess the current technology to assist the Air Force in implementing a cost-effective IGS for base-level engineering and to implement a prototype which demonstrates the initial IGS capabilities which are:

1. The capability to take large data bases, such as those for Base Comprehensive Plans, and put them on the existing WIMS equipment and access them through IGS.

2. The capability to automate drawing production.

3. The capability to interface with the WIMS data base, allowing users to attach the tabular data to the graphic features.

The technology assessment will be accomplished by

reviewing the literature and summarizing the current issues
to consider when choosing a system to support IGS.

The prototype development will be based on the IGS
objective to develop a system that will interface with WIMS
hardware and data base and offer a one terminal solution.

The demonstration of the prototype system will show the
integration of the system with WIMS, the integration of a
tabular data base with the graphics, loading of the graphic
data base and the application of a user interface.

Research Questions

To achieve the research objectives the following
questions should be answered:

1. To what extent, if any, can the Wang VS100 be used
to overcome the shortfalls of a microcomputer based system?

2. What will microcomputer based IGS do well?

3. What degree of functionality will be lost by
operating a microcomputer based IGS?

4. What was learned from the prototype that
can be applied to the development of IGS?

Scope

This research will be limited to the study of a
microcomputer based system and its interface with Wang
equipment because of the commitment the Air Force has made
to WIMS which is based on Wang equipment.

II. Literature Review

Introduction

Previous studies have researched the applicability of CADD to Air Force Civil Engineering and illustrated that the type of work done is not so unique that it cannot get the same benefits from CADD that civilian A-E firms, facility managers and small municipalities do.

In his thesis, Captain James P. Mitnik, surveyed Air Force Civil Engineering officers working in the Technical Design Section and compiled a list of CADD hardware and software requirements based on the results of the survey. What is apparent from that list is that design engineers have need for several different applications some of which would be best handled by microcomputers and others would be better suited for the power of a minicomputer (19:5.22).

Another point made in Captain Mitnik's thesis is that engineers need for CADD varies. There are those who require casual access and those who require full time access to all the power the system will yield (19:6.3).

Studies have also examined the appropriateness of one system versus another. One of the most frequently made comparison is between microcomputers and minicomputers. Major Neil H. Fravel concluded, in a report for Air Command and Staff College entitled <u>Microcomputer CADD and the Air Force Civil Engineer</u>, that:

...while some functionality is loss by stepping down from the miniCADD level to microCADD few engineering requirements at the base are beyond the capabilities of microCADD and at the cost of $6900 (his estimate of what a single PC would cost at the time) the payback gained by implementing microCADD today outweigh the marginal benefits gained by waiting for a fully integrated minicomputer system in the future. [11:33]

The most pervasive requirement, shared by all in Air Force Civil Engineering is the need to share information in a graphic format. Air Force Civil Engineering is very dependent on information displayed in a graphic format and is equally depended on the system that allows the sharing, review and manipulation of that information. What system will be suitable is the question that is currently getting the most attention. There probably is not one answer for all cases although in some cases the decision should probably be considered to have been made. The purpose of this chapter is to discuss the issues which need to be considered when deciding what system to choose.

Microcomputers vs Minicomputers

The decision has traditionally been one of choosing between two classifications of computer, microcomputers and minicomputers, when selecting a system appropriate for Air Force Civil Engineering. Minicomputers offered performance and microcomputers offered an affordable price. Major Fravel suggested in his study that, 'With an unlimited budget the decision between a miniCADD system and a microCADD system

would be easy" (11:17). The choice would be miniCADD. The choice has become less clear with the advent of workstations and the technological advances made in the microcomputer industry. From a performance stand point workstations are in about the same class as minicomputers so whereas the choice use to be one between minicomputers and microcomputers the choice is now between workstations and microcomputers (23:63).

The difference between workstations and microcomputers traditionally involved the type of microprocessor, operating system, memory size, graphic power, speed and storage capacity (4:39).

According to Cheryl Vedoe, group marketing manager for workstations and graphics at Apollo Computer Inc. "Three elements define a workstation. They are a dedicated high-performance, 32-bit central-processing unit, or CPU; high-performance, bit mapped graphics; and interconnections with other similar units through a network" (23:63).

Microprocessor Type

The device that made the personal workstation possible was the 32-bit microprocessor most of which are the Motorola 68000 series of chips (2:20). That microprocessor gave the workstation performance characteristics such as virtual memory and the capability to address large amounts of memory which were previously possible only on larger

computers. Virtual memory allows a computer to run programs that are larger than main memory by bringing parts of the program from the disk as they are needed and making it seem to the user that they have the full resource of the computer (4:54). It also permitted the development of low cost bit-mapped graphics, where each screen pixel has a specific memory location (2:20).

The Intel 80386 32-bit microprocessor has brought many microcomputers to parity with some workstations (1:69). Microcomputers which are equipped with the 80386 microprocessor have speed and memory capabilities close to those of a workstation except as limited by the software. The operating systems of microcomputers today are still 8-bit or 16-bit and do not take full advantage of the power of the 80386 microprocessor (23:71). Two features that are not being taken advantage of are multitasking and virtual memory (23:48). Multitasking, the ability to run more than one application at a time, is very useful in CADD. For example, with text databases becoming an integral part of CADD it would greatly enhance CADD functionality if the database management program and the CADD program could be run simultaneously (18:84). Although the full power of the 80386-based microcomputers is not currently being tapped with most applications standard software does run faster than it does on the 80286-based microcomputers.

Cost

Cost use to clearly distinguish microcomputers from workstations but more recently the two systems have been closer in cost. A good example of how the cost of workstations is approaching the cost of microcomputers is the SUN386i released in April of this year. This desktop computer, based on 32-bit architecture, comes standard with 91 Mb of hard disk storage and 4 Mb of Random Access Memory (RAM). Its operating system is a proprietary version of UNIX, called SUN/OS, and it has the capability to run UNIX and DOS (refer to Operating Systems) applications simultaneously. This microcomputer, classified as a workstation, list for approximately #11,000 (3:16).

David Nelson, Chief Technical Officer at Apollo Computer suggest that a tenfold improvement of computer technology occurs every seven years:

> Thus the virtual-memory capability of a #1 million IBM 370 mainframe computer, which first emerged in 1970, became available on the VAX in 1977 (for approximately #100,000) and in the Apollo DN300 workstation in 1984 (for approximately #10,000) By extrapolation, claims Nelson, that same capability ought to be available in 1991 for close to #1000. [2:20]

Graphic Power

When compared to the workstation, microcomputer graphics are slow. High speed graphics require a high speed processor and a high speed graphics adapter (4:42). The 386-based microcomputer can process information at high

2.5

speeds, but, to fully utilize its power the graphics adapter, which controls the information flow from the processor to the monitor, must be able to keep pace with the processor. IBMs Video Graphics Array (VGA), the high-end standard graphics system available for microcomputers, doesn't approach the graphic speed of workstation graphics (22:22).

Other distinctions between microcomputers and workstation graphics is screen size and resolution. Most workstations have 19 inch screens and high-resolution graphics. Microcomputer screens generally are 12 to 15 inches, and offer low resolution graphics. Resolution refers to the number of displayable dots, or pixels on a screen. The highest standard microcomputer resolution is 640 by 480 available under the VGA standard (23:63,69). Typical workstation resolution is around 1,024 X 1,024 pixels (4:46). Currently the highest resolution commercially available is around 2000 X 2000 pixels (1).

As is the case with most of the differences between microcomputers and workstations for a price the graphic power of a microcomputer can be modified to out perform workstations. For example, a high performance graphic package with a 19 inch, 1024 X 768 pixel color monitor and graphic controller can be added for about #3500 (33:19). But, there are inherent advantages to buying a fully integrated system from a single vendor which are discussed

in more detail later in this study.

The demand for workstation type graphic power on the microcomputer is frequently to meet the need of fast, realistic 3D graphics and easy manipulation of large graphic and nongraphic databases (4:42). Therefore, if 90% of a users applications are 2D and the remaining 10% require 3D most of the terminals on a system won,t have to support high resolution, high speed graphics.

Operating Systems

Most microcomputers run on Microsoft's Disk Operating System (MS-DOS) whereas most workstations run on AT&T's UNIX operating system. The operating system is what determines the compatibility of the application software. "PCs lack access to workstation software and workstations are generally incompatible with PC programs" (23:71). The reason this is an issue is because some of the features available only with UNIX are desirable, but, are not available with microcomputer systems running MS-DOS. Notably, multitasking, large addressable memory, virtual memory and transparent file sharing are not MS-DOS capabilities.

UNIX supports multitasking, the ability to run more than one program at the same time, has no limit on physical memory and will run on the 80286 and 80386 based microcomputers as well as higher performance workstations

giving it a feature known as ˙portability˙ (33:21). ˙In a multitasking UNIX environment a user can plot a drawing and work on a drawing at the same time, or run a spread sheet or word processor and CADD packages simultaneously˙ (33:21).

Currently features such as multi-tasking, virtual memory and transparent file sharing do not exist in the microcomputer CADD environment running MS-DOS (33:60). The new 80386 microprocessors supports multi-tasking, and can address up to 4 gigabytes of data (4000Mb), but, MS-DOS is not able to take advantage of that power. Its addressable memory is limited to 640K (.64 Mb) (33:21). When writing application programs for the MS-DOS operating system speed is sacrificed to save memory space because of this limitation (18:84).

The MS-DOS environment is not without some advantages. It has a large inexpensive library of application software for one. The same application software for UNIX would be expensive if available at all. This puts workstations at a disadvantage when viewed in terms of the single terminal concept, the idea that a terminal should be capable of being used for CADD applications as well as general office use such as word processing. Another advantage of MS-DOS is it is easier to use. UNIX is cryptic, meaning it doesn't resemble English, making it not as user friendly as MS-DOS. A new operating system for microcomputers from Microsoft for IBM, know as OS/2, may help to overcome some of the

limitations of MS-DOS. ` OS/2 introduces multi-tasking to the PC world and increases the addressable memory to 16 Mb` (33:21).

Speed

Speed or response time refers to the time a machine takes to process information and provide output. Output, in the case of CADD, usually refers to graphics on a computer monitor. One standard of system speed measurement is Million Instructions Per Second (MIPS). On the average a microcomputer is capable of processing .3 MIPS whereas a workstation is capable of processing 4 MIPS or more.

How fast is fast enough depends on what the user wants to do. When working in a 2D environment response times between .10 to .25 seconds are considered to be acceptable (26:74). When wanting to revolve a 3D model, in real time, no delay is acceptable.

Most CADD experts say a 286-based microcomputers can handle 95% of all 2D drawings with adequate response times (26:67). If true 3D or real-time image manipulation is needed a special purpose workstation.would better serve the purpose.

Hardware enhancements such as graphic accelerators and floating-point coprocessors and expanded memory can get more speed out of a microcomputer. For example a floating-point coprocessor can produce processing speeds of 1 MIPS

(4:48). The problem with hardware enhancements is by the time a microcomputer's performance is improved to the extent that it approaches a low-end workstation the cost advantage of the microcomputer is lost (4:48).

In a 2D environment a 286-based microcomputer can create graphics at an acceptable speed. The microcomputers lack of speed becomes more apparent when a screen is completely redrawn particularly if its a large design file.

Storage Capacity

A microcomputer generally comes with an initial 20 Mb of hard disk expandable in increments of 20 Mb to 100 Mb. The graphic data storage capacity required for an average airbase is relatively large. A single base map draw at a scale of 1˙ = 400' could require as much as 2 Mb just to store the graphic data. 'As a rule of thumb, applications that require very large databases, say more than 200 megabytes, might call for mainframe solutions and midrange capacities are the province of file servers˙ (4:74). A file server is usually a microcomputer or minicomputer with large disk storage capacity. The microcomputer or workstation accesses the file servers stored data using specially designed access software and downloads it to its own hard disk through either a telephone connection or direct cable connection. When using a file server the data must be downloaded to be manipulated. It cannot be manipulated when

it resides on the servers disk. After being manipulated it can be uploaded to the file server until it is needed.

Networking and Datasharing

Architectural design and production is a group effort which involves teams of people working together on projects involving many drawings therefore sharing information between machines is very important (33:21).

Another consideration in choosing a CADD platform is networking and database sharing.

> A true distributed network has each processor take on special responsibilities. This calls for a system that let processors share data and programs rather than merely transfer files. Such a system ensures that there is only one copy of a file to maintain consistency and save file space. PCs originally intended as single user machines, transmitted at relatively low speeds and could not be connected easily to high-speed networks like Ethernet. In systems where files are stored on a central file server problems can arise, as when several users alter copies of the same file and send the different versions back. The server has no idea which file is the correct one. Small organizations may be able to manage this without an independent file manager, but large organizations need more control over files. Workstations generally offer a distributed file system, so users work from one file located on any node in the network, not from multiple copies of a file. [4:50]

The limitation on the networking of microcomputers has been and still is a software problem, not a hardware problem. "A workstation based on a UNIX operating system has networking built in whereas the MS-DOS based microcomputer does have that capability" (18:83).

Integrating Databases

An issue that is addressed in this study is the link between graphics and a non-graphic database. This is what takes CADD beyond automated drafting and brings information in a graphic form out of the domain of draftsmen and engineers and into the mainstream of an organization in the form of an integrated graphics system.

A database interface is another example of an application which use to be the province of minicomputers but, has now migrated to the microcomputer.

Some examples of database applications in support of engineering design are quantity takeoffs for estimating, providing input to a specification system, and space planning. 'Databases are where the CADD payoff really begins,' says Anthony Mirante, director of computer services at Gensler & Associates. 'The ability to capture information and continually reuse it in different applications is the real benefit of CADD' (17:39).

'People are just starting to realize that a drawing is more valuable inside a computer than on a drafting board,' observes Walter Popen, president of CAI Computer Services Inc. 'Users need to go beyond getting their drawings done. They need to boot up there system and interact with there drawings and take advantage of CADD's real power' (17:39). 'Facility engineers need two types of information-graphical and nongraphical. A single integrated database that

contains both graphics and relational information can provide both types of information" (16:51). Most bases have developed or are in the process of developing their nongraphic database on the WIMS.

Building the Graphic Database

One of the most important issues to consider when choosing a CADD system is that systems compatibility with any existing graphic databases. The importance of this consideration should not be underestimated because techniques used to input or translate drawings into the graphic database can be time consuming, expensive and inaccurate

The Air Force has made and is continuing to make a substantial investment in its graphic database in the form of Base Comprehensive Plans (BCP). These are extensive in scope, beyond in house capability with average of fees $1.5 million (5:2). All BCPs require a digitized graphic database furnished on magnetic tape. Sixty six projects have been funded and thirty six projects are planned for the future (5:2). All projects include CADD mapping and are being done on various minicomputer systems and some microcomputer systems (1). The Wright-Patterson BCP called for all existing above grade structures and natural features to be mapped and digitized at 1"= 400' and 1"= 50' scales. The total contract cost was $1.9 million of which

$500,000 was for the mapping and digitizing of the existing conditions. In comparison Wright-Patterson spent $450,000 on their mini-based CADD system. This represents a nearly equal investment in the database and the CADD system that uses it which makes the compatibility issue all that more important. The standard BCP Statement of Work request that the database be provided on a 1600 BPI magnetic tape in the Initial Graphics Exchange System (IGES) format. This file format can be used by most any system a base may get. However translation is still required and 100% accurate translation in IGES is nearly impossible (1).

The BCP will be the start of the graphic database for most bases. Bases will add to this in one of several ways. If the graphic data is in the form of existing drawings, there is generally three ways to input it into a CADD system, manual redraw, digitizing and pixel scanning (12:77) Redrawing requires that an existing drawing be redrawn using a CADD system. Manual digitizing requires an operator to trace over an existing drawing using a digitizing tablet and a puck. Pixel scanners automate drawing input by scanning the existing drawing with a light source and converting from pixel to raster format (12:77). If the database is digitized but in a format other than that of the system being used than a translator will be required.

Large projects such as those in the Military Construction Program which are usually designed by

commercial architect-engineering firms may be design on the firms CADD system. This will also serve to contribute to a bases graphic database.

What is necessary to load the data will directly effect productivity. This is particularly true in the Air Force because the majority of the graphic data used will not be initially created on the microcomputer, but rather it will be created on other systems, probably minicomputer based, by outside consultants or a design agent such as the Army Corp of Engineers or Naval Facilities Engineering.

A CADD feasibility study done for Wright-Patterson AFB demonstrated that it will take 313 man years to update the bases as-built drawings (28:3-18). This tends to indicate that graphic databases are not going to be built from within the system but from outside sources. The manpower is not available to manually digitizing a bases as-builts. This makes an excellent case for CADD because the highest productivity gains come from modifying and updating existing drawings rather than from creating drawings initially (11:15). It is the repetitiveness of the work, maintaining and altering the same set of buildings, which really makes CADD profitable for the Air Force as it does for other institution such as universities and municipalities.

III. Methodology

Overview

This chapter describes the methodology used to accomplish the research objectives and answer the research questions. The technology assessment was accomplished by reviewing the literature and summarizing the current issues to consider when choosing a system to support IGS.

The prototype development was based on the IGS objective to develop a system that will interface with the WIMS hardware and data base and offer a one terminal solution.

Commercially available, microcomputer CADD software and hardware was integrated into a prototype system and its performance was evaluated by running a demonstration incorporating four major applications; user interface, text database interface, Wang VS100 interface and large graphic database interface.

The research questions were as follows:

1. To what extent, if any, can the Wang VS100 be used to overcome the shortfalls of a microcomputer based system?

2. What will microcomputer based IGS do particularly well?

3. What degree of functionality will be lost by operating a microcomputer based IGS?

4. What was learned from the prototype that can be applied to IGS?

Justification of Approach

Demonstrations on vendor's systems are frequently used to give users a first look at a CADD system. Unfortunately, it is difficult to determine from a standard demonstration what the true potential of a system is for a specific application (7:618). It is particularly difficult to evaluate system performance when it is comprised of components from several vendors. Without physically integrating the various components you cannot identify incompatibility problems, for example. CADD advantages are not as well explained as they are demonstrated therefore the chosen method of showing the prototypes capability was a hands-on demonstration on a system integrated by the researcher. The researcher felt that a demonstration tailored to specific applications of Air Force Civil Engineering would best serve the purpose.

The Demonstration

Putting together the demonstration involved the following steps; acquiring the hardware and software and integrating it into a system, building a database of graphic and text data and building a database interface and a user interface. Each step is explained in detail in the

following paragraphs.

The Prototype

The software and hardware were loaned to the AFIT
School of Civil Engineering and Services for the express
purpose of research and evaluation and was returned when
the study was completed. The prototype was comprised of the
following software and hardware.

The CADD Software

Intergraph's Microstation software was chosen as the
CADD software for the demonstration. The initial reason for
selecting this package was its compatibility with the
existing graphic database. The graphic data was created on a
Intergraph mini-based system with Intergraph's Interactive
Graphic Design Software (IGDS). IGDS and Microstation used
identical design file formats, cell libraries and input
menus (20:102).

If compatibility had not been the first and foremost
consideration another software could have been chosen and
it would have been necessary to translate the existing IGDS
graphic data so it could be used by that software. DXF,
AutoCAD's file format, is probably the second largest
graphic database in the Air Force, the first being IGDS (1).
Intergraph's Micro-CADD Marketing department has evaluated
the performance of four Intergraph to/from AutoCAD

translators on the basis of speed, ease of use, and accuracy. What was learned from that evaluation was that no error translation can be achieved at a cost roughly equivalent to what the Microstation software cost.

Cost may not always be the first consideration. Often if operators are trained on one system translation will be chosen over changing system software and having to retrain operators. Microstation's release 3.0 will support the DXF format eliminating the need to translate AutoCAD files to IGDS. In the case of this study the researcher had no experience on any CADD system so previous experience did not drive any software selection.

The Hardware

The CADD platform used in the demonstration was a Wang PC 380 which is a 80386 32-bit microprocessor based microcomputer with a speed rating of 16MHz (Figure 3.1). It came with 512 kilobytes of Random Access Memory (RAM) with 2 Mb of 32-bit RAM Extension expandable to a maximum of 10.5 Mb. It contained one 1.2 Mb diskette drive and 40 Mb of hard disk. A 80287 math co-processor module, which is required to run Microstation, was added to speed up complex mathematical calculations. The monitor used was a Wang MON-1450 EGA quality, medium resolution 14 inch monitor. The microcomputer was not configured to support two monitors although the software could. The PC 380 came with Wang's

3.4
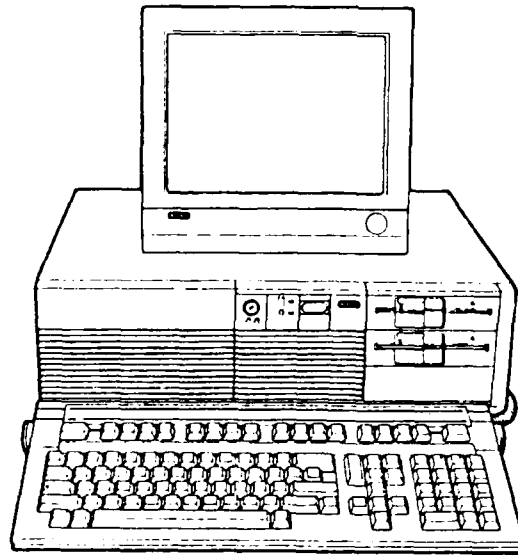
Figure 3.1. Wang PC 380

standard IBM compatible keyboard. The microcomputer, monitor
and math co-processor were loaned to the AFIT for evaluation
by Wang Laboratories, Inc.

The Wang PC 380 was chosen as the CADD platform for two
reasons. First, 80386-based microcomputer's are currently
the high-end performers in the microcomputer based CADD
industry and there was strong interest in testing its speed.
Secondly the Wang PC 380 offered the added advantage of also
being capable of operating as a WIMS terminal which was
important when accessing the Wang VS100. Because it was
equipped with the Wang keyboard it was not necessary to
remap the PF keys which would have been necessary if, for
example, the Zenith Z-248 microcomputer (the Air Force's
current desktop standard) was used.

3.5

Input and Output Devices

The chosen CADD software platform, Microstation, supports the following input devices; mouse, digitizing tablet and keyboard. What device to use is usually a matter of personal preference. All three devices were used in this demonstration.

Building the Graphic Database

Building the database for the demonstration involved two problems. First, where to get a database of sufficient size and type of graphics common to an airbase and secondly how to download that graphic database to the microcomputer. Creating the graphic database on the microcomputer would have been well beyond the scope of this study and down loading graphic data created on a minicomputer via a file server provided an opportunity to test that aspects of the system.

The graphic database came from two sources. Individual building graphic files came from Wright-Patterson's Base Civil Engineering Technical Design section which created them on an Intergraph 200 minicomputer system. The remainder of the graphic files were provided by Woolpert Consultants (under contract with Wright-Patterson AFB to do the Base Comprehensive Plan [BCP]) and were prefinal drawings which are part of the BCP for Wright-Patterson AFB, loaned to AFIT for this study.

Transferring Files

The transfer of graphic data to the microcomputer's hard disk so that it could be accessed by the CADD software was an essential first step to setting up the prototype. Two methods were used to download the files to the microcomputer. The method used depended on the size of the graphic file. If the file was 1.2 Mb or less it could be transferred to the microcomputer using a high density floppy diskette. If the file size exceeded the 1.2 Mb it could not be split between two diskettes, therefore, the file had to be transferred to the microcomputer via a file server using a magnetic tape.

The File Server

A Wang VS100 minicomputer was used as the file server. Graphic data was transferred from Intergraph 200 to the Wang VS100 by 1600 BPI magnetic tape and was loaded to one of the Wang VS100's 280 Mb disk volumes. The Wang VS100's tape drives and their controllers are compatible with industry standards and are designed to facilitate information interchange between the Wang VS100 and other computer systems.

The Data Exchange Software

Wang's PC/VS Data Exchange software was used to convert and interchange the graphic data between the Wang VS100's

disk volume and the microcomputers hard disk. Also required to make this work was VS Access software residing on the Wang VS100.

The User Interface

The user interface chosen was an on-screen menu (Refer to Appendix A) primarily because when Microstation boots up it presents an empty screen and there is no indication as to what to do next. The intent of the on screen menu was to provide the user a quick and easy access to information without having to refer to a manual. The interface was programmed using Microstation's macro language 'User Commands'. Macros are a method of memorizing multiple keystrokes and functions to accomplish a task which would otherwise require lengthy keyboard input. The demonstration shows the use of the macro language to make the user interface more friendly by using screen menus and by facilitating access to graphic data when very little information or system understanding is know.

The Database Interface

Ashton-Tate's dBase III Plus was chosen as the database manager because Microstation supported an interface with this software and because the text database also provided by Woolpert Consultants was created using it. The program dBASE III Plus is a programmable relational database manager

meaning `it can draw information from more than one file at a time. The means used to link, or relate, the data in those files gives rise to the term relational` (25:154). For example a user may w:nt to calculate the replacement cost of a facility. One file might contain the real estate information which would provide the square footage for the facility and another file may contain cost data for facility construction. The programmable feature of the program could be used to merge the selected records from each file into a report and execute a mathematical function to calculate replacement cost. The program dBASE III Plus can open and access a maximum of 10 files simultaneously. However, Microstation can only open and access 3 of those files at one time. This amount of database power is akin to the power of Microstation in that it once was available only on minicomputers and has since migrated to the microcomputer (24:122).

The intent of this part of the demonstration was to link database files containing text data to the graphic data and allow a user to access that information while in the design environment, display it in a full screen format and add or delete new records to the attached database.

The text database used was provided by Woolpert Consultants who constructed it as part of Wright-Pattersons BCP. Although the database was eventually to be used on the Intergraph 200 with DMRS, Intergraph's minicomputer based

3.9

Data Management and Retrieval System, Woolpert Consultants found it easier to construct the database in dBASE III Plus first and then translate it to DMRS rather than write it in DMRS originally. When the database was furnished for this study no translation was required and only the linkage of the graphic elements to the database had to be accomplished. Databases originally built on the Intergraph 200 using DMRS would only be accessible to a microcomputer based system using third person software such as Peter A. Johnson & Associates' MFCbase.

Speed Test

The intent of this part of the demonstration was to compare the speed that the demonstration would run at on a 286-based machine to that of a 386-based machine. Only the graphics, determined to be the most time sensitive, were tested. Identical graphic files were loaded on a Zenith Z-248 the Air Forces 286-based desk-top standard and the Wang PC 380, the prototype 386-based machine. First the speed of the initial load was tested than the regeneration of the drawing on the screen was tested.

Compatibility

The underlying issue which involve all aspects of the integration was compatibility. In some cases an ideo-syncrasy in the hardware or software prevents the components

from working together 100% of the time. The method used to determine compatibility was simply to physically integrate all the components and if they worked they were compatible.

IV. Findings

Introduction

This chapter discusses the finding of the prototype
integration and evaluation. The aspects discussed are
building the database, integrating the prototype, the user
interface and database interface.

Transferring Files

All of the files used to build the graphic database
were created on an Intergraph 200 in Intergraph's IGDS file
format. They had to be transferred via some medium to the
microcomputer in a format which was compatible with the
microcomputer's operating system and software. The
Intergraph 200 was equipped with a 1600 BPI tapedrive and
each of the workstations linked to it had one 5 1/4 inch
high density 1.2 Mb floppy disk drive. The following is an
account of the findings as they apply to that file transfer
process.

Transferring Files using Diskettes

Transferring files by high density floppy required that
the files be written to the floppy in MS-DOS format so the
MS-DOS operating system of the microcomputer would accept
them. The first step was to upload the design file from the
Intergraph 200 to an Interview 32C workstation linked to it

which was equipped with a 1.2 Mb floppy disk drive. Transfer of files from the Intergraph 200 to the Interview 32C workstation required a working knowledge of UNIX, the operating system of the workstation. Most users of the workstation had not worked in the UNIX environment because the CADD package, IGDS, resides on the Intergraph 200 in the VMS operating environment and the workstation was essentially being used as a remote dependent terminal. No CADD software was resident on the workstation. Appendix E contains the UNIX operating system commands required to load a design file from the Intergraph 200's disk volume to the workstation hard disk.

The design file could not be loaded directly from the workstations hard disk to the floppy because it would be in UNIX file format and not be recognizable to the microcomputer operating system. A section of the workstations hard disk had to be partitioned off from the UNIX environment and set up as a virtual MS-DOS operating environment by loading MS-DOS on that portion of the disk. The design file than had to be copied from the UNIX environment to the MS-DOS environment. UNIX to DOS (UTD) and DOS to UNIX (DTU) utilities come standard with the UNIX operating system. Appendix E list the commands for this procedure. Once the file was loaded in the MS-DOS operating environment it could be copied on to a floppy diskette.The UNIX to DOS utility also allows the direct transfer of files

from the workstations hard disk to the floppy without copying them to a DOS partition. See Appendix E for the procedure for copying files directly to the floppy using the UTD and DTU utilities.

The procedure for transferring files by floppy diskette was straight forward and well documented. The limitation of this method was file size. The size of the file being transferred was limited to the capacity of a single floppy, 1.2 Mb. Files could not be continued on a second floppy if they exceeded 1.2 Mb.

Transferring Files Using Magnetic Tape

Whereas the procedure for downloading files using a floppy, although limited by file size, was a fairly strait forward procedure and well documented by Intergraph, file transfer by magnetic tape presented several problems. In particular, the system the design file was created on was not the same as the system being used as the file server. The issues of multi-system compatibility and multi-system support became important. Each vendor of the two systems involved was familiar only with their respective systems.

The approach was to copy the file in the most generic format possible to avoid any proprietary labels or structures which would create an incompatibility problem. The first attempt involved using the tape backup utility on both the Intergraph 200 and the Wang VS100. This attempt

failed because the tape backup utility on the Intergraph 200 restructures the file and the tape dump utility on the Wang VS100 could not restore it.

The second attempt involved using the COPY utility on the Intergraph 200 with a NOHEADER qualifier and the TAPECOPY utility on the Wang VS100. The first attempt at this failed because multiple files were copied to the tape and the Wang VS100 could not recognize were one file ended and the next one began. The second attempt was successful when a single file was copied on the tape. See Appendix E for the procedure required to execute the COPY utility and Appendix F for the TAPECOPY utility.

An area that may need further clarification is describing the tape record format for the TAPECOPY utility. (refer to screen 0002 of the TAPECOPY utility, Appendix F) The Intergraph 200 file format is fixed at 512 records/block. The block size entered for a fixed-length record must be an even multiple of the record size.

File transfer between the two systems presented no major incompatibility problems except a minor problem with the end-of-file (EOF) markers. The EOF marker that Intergraph 200's COPY utility put on the magnetic tape was not recognized by the Wang VS100 TAPECOPY utility. This precluded the transfer of more than one file at a time by tape.

The tape drive of the Wang VS100 was designed to

facilitate information interchange between the Wang VS100 and other computer systems and did so with one minor problem, the block size. The Intergraph 200's default block size setting is 16383 bytes. The initial attempt at copying the files failed because Wang's maximum block size was 6400. This was only a problem when the BACKUP utility was attempted and became a non-issue once the COPY utility was used.

Setting Up a File Server

Once a file was successfully copied to the Wang VS100 disk volume the next step was to down load it to the microcomputer's hard disk. This required two operations.

First, a hardware connection had to be made between the microcomputer and the Wang VS100. A 16-bit data communications card had to be installed in the microcomputer and a dual coaxial cable was used to connect the microcomputer to the server. The Wang VS100 system administrator had to configure the port on the Wang VS100, that the coaxial cable connected to, as a 2246S, 2256C or 2256MWS workstation (31:2-28). The communication card used was a Wang Local Office Connection (VS-WLOC-PC2) which is the same communications card used to support the Wang PC 200/300 Series.

The software required to transfer files between the microcomputer and the Wang VS100 was PC/VS Data Exchange,

which resides on the microcomputer, and the VS ACCESS which resides on the Wang VS100 (30:1-1). MS-DOS Release 3.1 or greater is required to run this software on the microcomputer. The microcomputer must also have a minimum of 384 KB of memory.

The process involved in transferring the files is strait forward for the most part. Appendix D contains the print outs of the screen menus used in the process.

One area of the file transfer process which may need further explanation is specifying the data types for input and output. The PC/VS Access menu presents the user with nine input and output data types from which one input and one output data type is chosen. The input data type should be VS consecutive and the output data type should be PC stream. VS consecutive files are basically the same as PC text files (32:2-4). The record length of Intergraph 200's design files is fixed. The record length of a consecutive file can be fixed or variable (32:2-4). Stream files are PC files that do not have any physical record structure. 'Specific applications that use stream files give structure to the data' (32:2-9).

Of particular interest to anyone who wants to transfer large files and/or a large number of files is the time it takes to complete a file transfer. The transfer rate is 7.5 kilobytes/sec which for a large design file can take 3 to 5 minutes.

The User Interface

The User Interface was designed as a simple example of how the system could be programmed to allow the user to interact with different design files and acquire information without knowing much about the system (Refer to Appendix A: Demonstration Screen Views).

The user interface was initialized from the Wang applications menu. Transparent to the user is the initial boot up of Microstation, loading the design file IGS.DGN and execution of the screen menu with the command UC=MENU. IGS.DGN presents a four view screen with a Vicinity Map in view 1 (Page A.1). The on-screen menu in view 3 presents the user with six selections (Page A.2). A selection is made by placing a data point on the text within one of the menu blocks with the puck or mouse.

The first menu block 'Tutorial' was design to walk the user through all the steps of the interface. Each of the other four selections is a subroutine of the Tutorial designed to allow a user to look at any part of the tutorial without having to go through it sequentially. The following discussion generally describes the tutorial and in so doing describes the four subroutines.

The Tutorial routine prompts the user to select from the five areas displayed on the Vicinity Map displayed in view 1. When the user enters a number a reference file of a

keymap divided into 50 scale keymap areas is displayed in view 4 (Page A.3). The user is than prompted to select an area of interest from the keymap at which time a full screen view of that area is displayed in view 5 (Page A.4,A.5). The user is then prompted to input either a facility number or place a data point on the facility after which the first floor plan of the facility is displayed (Page A.6). The user is then prompted to keyin 'Enter' to display the data on the facility selected. The tutorial can be exited at any time by hitting the reset button on the mouse.

The interface is supported by programmable macro files called 'User Commands'. User Commands (UCMs) allow a user to customize Microstation for an application by writing programs that automate user input, test and loop for expected conditions, perform arithmetic operations, and simulate operator input to Microstation (13:2-1).

This interface required six separate macro programs, MENU.UCM, TUTOR.UCM, VICMAP.UCM, KEYMAP.UCM, PLAN.UCM, DATA.UCM, and a database file named MENU.DBF with its supplemental files. These are ASCII files that were created with a text editor called PCEdit.

MENU.UCM attaches a reference file, SCREEN.DGN, with the graphics of the screen menu which appear in view 3. Each text node on the menu is attached to a database record in MENU.DBF using the method describe in the section on Database Interface. Each text node contains the underlying

user commands and keyins. The remaining user commands are all executed from this menu by placing a data point on the text node corresponding to the command the user wants to execute. All the macros work in a similar manner calling in different reference files or database records.

The Database Interface

To demonstrate the concept of having text data associated with a drawing a database of real property information was linked to buildings on a base map. From within the CADD environment a user could access, review and edit this information. The user interface provided two ways to indicate what facility the user desired information on. The user could (1) place a data point on the building or (2) enter the facility number. The following paragraphs describe how this is done. It basically involves three components, the database, the drawing and the link between the two.

The database management package dBASE III Plus is a widely know and well documented package. Learning how to use it requires some time. The purpose of this discussion is not to explain it in detail but to provide some basics so the interface can be understood. This discussion will be limited to those aspects of the database involved in the interface.

The database structure defines the name, type and size

of each data field. This structure is define by the user initially before any data is entered. The data structure for WPAFB.DBF is shown in Appendix C. One of the data fields is named MSLINK. This is a numeric type field with a maximum size of 10 characters. This is the field that Microstation keys on when locating records in the database.

The database manager dBASE III allows a user to arrange records in a database file according to the value of an indexing key. An indexing key can be any field of records in the database. In order for Microstation to locate a record in the database an index file must be created that is keyed on the MSLINK field. This index file must be available in the same directory in which the database file resides. In addition, the MSLINK index file must have the same filename as the database, but with a .MSL extension (14:8-2). This file is referred to as the master index file. The master index file for this example is WPAFB.MSL. Aside from this index file a user can create a maximum of two additional index files per database. Each of these files can be keyed on any field the user may want to query. In this example an index file has been created which is keyed on the field FCLTY which contains the facility numbers. This file is named FCLTY.NDX. The .NDX extension is the convention for index files other than the master index file.

On the database side of the interface there are two other dBASE III file required. One is a screen format file

which is used for displaying and editing database records from within Microstation. In this example that file is named WPAFB.FMT. The REVIEW command in Microstation displays the information on a record in the format specified by this file.

The remaining file is the control file, IGSCTRL.DBF which must be created to associate the design file, which in this case is IGS.DGN, with its corresponding database, index files and screen format files. A blank control file is provided with Microstation. This file has a specific structure which cannot be modified so it is just a matter of defining the correct file names. This is done from within the design environment using a SET DATA command. When SET DATA is keyed in a full screen display of the control file comes up in edit mode.

The control file format allows for a maximum of three databases to be open at anyone time. In this example only two databases were opened. The control file format allows for two index files in addition to the master index file per database. In this example one index file FCLTY.NDX was specified. The master index file was specified in the remaining open space, but, this is not necessary when the space is needed for a second index file.

The SET CONTROL command is used to initially attach the control file to the design file. This command is input from within Microstation's design environment.

Establishing the Link

The second part of the database interface was to establish the link between the database files created in dBASE III Plus and the design file. The demonstration employed two ways to associate the graphics with the text data. The method used was to link a graphic element to a specific record in the database. A graphic element can be a line, circle or arc, for example, or it can be a group of those. In this case the facility number text node on the base map was attached to the corresponding records in the database containing the information for that facility. Linking the text nodes to the data record for that element required four steps which are explained in detail in the following paragraphs.

Microstation associates graphic elements to a database record with two variables, an entity number and an MSLINK number. The entity number is the number of the database and is specified in the control file as a value of 1,2 or 3. The MSLINK number corresponds to a specific record within that database. Both the entity number and the MSLINK number are stored in the graphic file in a buffer called DGNBUF.

The linkages between the facility and its corresponding database record is established by using the ATTACH AE command. Before this linkage can be established the record in the database must be located and made active. This is done by using the FIND command. The FIND command requires

the user to input the entity number, or alias, of the database where the record is located and the name and value of the field that corresponds to the record. In order to locate an element there must be an open index file which is keyed on the field which is named when executing the FIND command. Microstation opens the master index file (MSLINK file) automatically and allows two other index files to be open at any one time providing up to three possible index files in which to search for records (13:1-178).

Once the active entity is defined than the ATTACH AE command can be executed. It will prompt the user to identify the element to be linked to the active entity. This is done by placing a data point on the that element with the mouse or puck.

The facility is know attached to a record in the database. The data can know be reviewed and edited from within the design environment. The REVIEW command is used to interactively review the data record, the EDIT AE command is used to edit and the CREATE ENTITY command is used to add a record.

The user command operators central to the database interface are DBREAD and DBWRITE. These two operators allow User Commands to read and write records to and from an attached database (14:8-10).

System Integration: CADD Software

Microstation is an example of the migration of minicomputer capability to the microcomputer (21:102). It was designed from the start to emulate Intergraph's turnkey mini-based system (20:172). 'As a result it has approximately 80% of the functions found in the workstation and the commands are, with few exception, the same on the microcomputer and the workstation' (20:172).

The microcomputer and workstation having the same command language in effect allows a user to be trained on two systems simultaneously. This proved to be a tremendous benefit when putting this demonstration together. It afforded the researcher the flexibility to work with the design files on either the microcomputer or Intergraph's Interpro 32C workstation (Figure 4.1) without having to take
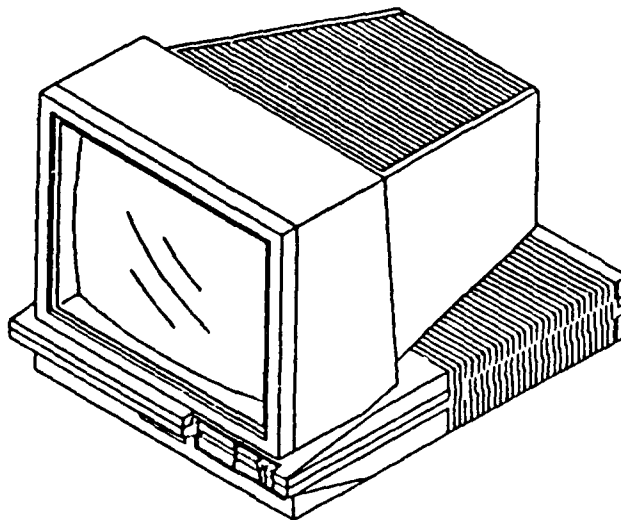
Figure 4.1. Interpro 32C

the time to learn two different command languages. This is part of a concept Intergraph calls 'vertical expansion'. It lets a user become familiar with the system at the microcomputer level and than upgrade to a workstation or mini-based system with a very little retraining.

System Integration: The Hardware

The primary objectives in testing the hardware was to test for speed and compatibility.

Testing for speed involved two aspects. First the capability of the system as it compared to a 80286 based machine which would serve to build a case for the 80386 based microcomputer. Secondly, the systems performance of the task at hand not as it compared to another system but just how it performed the job.

Compatibility is sometimes over look when putting together a system until it brings everything to a halt. Although software and hardware are supposed to be compatible they are not always 100% compatible. The check for compatibility is simple enough. It involves running the system components together and if the system does what it is supposed to, compatibility exists. For example, Wang Labs was very interested to know, as was the Air Force, if Wang's PC 380 was 100% compatible with Microstation or if some idiosyncrasy was going to keep the software and hardware from running together. Based on the results of this

demonstration no insurmountable incompatibilities existed in
this combination of hardware and software or in any other
combination used in the demonstration.

V. Conclusions and Recommendations

Conclusions

As power and cost become less of an issue when choosing between a micro-based system and mini-based system, a new set of issues are emerging. Some of these issues are compatibility, flexibility and customer support.

Compatibility needs to be addressed on two levels, hardware/software compatibility and software/data compatibility. If a investment has been made in an existing operating environment, file format and data creation then any future system should be bought with compatibility as a primary consideration.

Flexibility refers to the single terminal concept, the idea that a single terminal can satisfy all a user's requirements for CADD and office automation.

Customer support is an issue of equal importance. Generally there are three ways to build a system. They are (1) buy everything from a single vendor (2) buy separate components and integrate them and (3) hire a system integrator that works out the incompatibility problems. Without good customer support systems run less efficiently, if at all. Vendor support was critical to the integration of the prototype as it is for any computer set up. Multi-vendor interface problems were always more difficult to solve because each vendor knows their respective systems but few

5.1

vendors are familiar with how their system interfaces with another vendor's system. Those parts of the procedure that involved a single vendor were well documented. When the procedure involves multiple vendors' equipment there was no documentation. Vendor support was very important in setting up the file server. Fortunately the interchange software, the file server and the microcomputers were all Wang products.

CADD technology changes rapidly, making it difficult to make a decision on what system to purchase because there is always bigger, better, faster technology just around the corner. In the private sector making a decision at a given point in time can usually be justified by a short payback period. Unfortunately, the Air Force does not operate to make money so this sort of justification is usually preempted by other priorities. Because little money is available to purchase CADD systems two decisions should probably be considered to be made. First the system will be a micro-based system as opposed to mini-based or a workstation. Secondly, in light of the first decision any opportunity to overcome the limitations inherent in the micro-based system should be taken advantage of. This can be accomplished most economically by selecting a system which could be integrated with the existing Wang computer system and include the single terminal concept.

The Wang VS100 connection can serve to retain at some

advantages usually lost when going with a microbased system. The Wang VS100 connection allows the microcomputer to take advantage of the storage capacity of a large system. The Wang VS100 can function as a file server for the PC 380 with no additional hardware or software other than that required to support the Wang PC 200/300 series local office communications.

However, simultaneous multiple user access to the graphic database is not possible using the Wang VS100 as a file server. In systems where files are stored on a central file server, like the Wang VS100, several users can alter copies of the same file and when these different copies are reloaded to the file server each copy will be overwritten by the one following it.

There is 100% compatibility between the graphic data created on the Intergraph 200 system in IGDS format and the Wang PC 380 running Microstation. No conversions were required and no data was lost in stepping down to the microcomputer.

With the correct parameters specified, graphic data can be transferred by magnetic tape from the Intergraph 200 to the Wang PC 380 via the Wang VS100 with no conversion or loss of data. The single file limitation of the magnetic tapes can probably be resolved without too much difficulty.

The size of graphic files common to Air Force Engineering mandate a file transfer system with a capacity

of magnetic tapes. Floppy disk are limited by file size and although convenient, would not serve well as the only file transfer medium.

The following conclusions are based on the findings as they apply to the microcomputer and the micro-base software. In general, a user can store, access, manipulate, review and maintain a relational database and graphic data base at a microcomputers level, with little loss of functionality. Some sacrifices are made in terms of speed, multi-tasking and graphic power.

The speed of the 386-based microcomputer is a noticeable improvement over the 286-based microcomputer in respect to the initial load and redraw functions when manipulating the large graphic files common to Air Force Engineering. This speed advantage came from the enhanced processor time.

The inability of the microcomputers to support multi-tasking was a detriment when using the database interface. The capability to run both the database manager and the CADD software package would have improved productivity. Microstation supports a feature which allows the user to push to DOS while Microstation is still running. This feature largely went unused because Microstation uses most of the memory available under MS-DOS (640K) so no other application requiring memory could be executed.

A noticeable hardware short fall was the limitation of

the screen size and the single screen operation. Microstation supported dual screen operation but the hardware required for dual screen operations was not available for this study. The software supports up to eight views of a drawing. On a one-monitor system, four of the views are on a virtual screen and on a dual-monitor system four views are displayed on each screen. This demonstration would have been more effective with a dual-screen capability. In reference to screen size the 14-inch screen was acceptable for most applications except when viewing large scale drawing such as the C-1 Tabs (1'-400' scale).

The demonstration of the CADD software focused on features other than automated drafting. Features such as the database interface and user command language which broaden the applications of the software and brings it more in line with the concept of IGS. The database interface and user command features required some time to learn, but, once the process was understood it offered the flexibility to custom make applications. The user command language suffered from a lack of comprehensive documentation as did the CADD software as a whole. Learning to use the automated drafting features of Microstation was not found to be any more difficult than other CADD packages despite the documentation. The capability to move from a mini-based system to a micro-based system without learning a new command language was a tremendous asset.

Recommendations

These recommendations for further study follow a basic concept that a closer look needs to be taken at ways to fully exploit the equipment bought in support of WIMS.

The concept of a Unix/DOS dual operating system on the microcomputers seems to be one that would almost eliminate the disadvantages of a microbased system. It would allow multi-tasking and networking and virtual memory. Recommend a prototype system be set up and evaluated based on this system. PC IN/ix has been developed by Interactive Systems Corporation for use on the Wang microcomputers. This operating system is based on AT&T's System V UNIX system. Among the features this operating system supports are multiple operating systems on the same hard disk. (IN/ix and MS-DOS for example). It also supports UTD and DTU utilities and multiuser/multi-tasking capabilities. Recommend the study follow this study in the respect that a demonstration be designed that shows the systems capabilities in a way that Air Force Civil Engineering personnel can easily relate to.

The Wang VS100 located at each base may be an untapped resource with respect to CADD. This machine is based on 32-bit architecture, is configured for 8 megabytes of memory, can support up to 128 workstations and supports communications and network access. This study has shown that

it can be used as a file server. Other research could
explore its other potential uses. Wang UVS is a fully-
supported, standard version of the *UNIX System V software*
for the VS series of computers. A user can log onto the VS
in the VS mode and, with a single key stroke, can transfer
into the UNIX environment, and ice versa.

VICINITY MAP: VIEW 1

SCREEN MENU: VIEW 3

MENU SELECTION

TUTORIAL

VICINITY
MAP

KEMAP
AREA

FACILITY
PLAN

FACILITY +
DATA

EXIT
MENU

A.2

KEY MAP

R56		V56	X56		
R53	T53	V53	X53		
R51	T51	V51	X51	Z51	
R48	T48	V48	X48	Z48	CC48
R46	T46	V46	X46	Z46	CC46
R43	T43	V43	X43	Z43	CC43	EE43
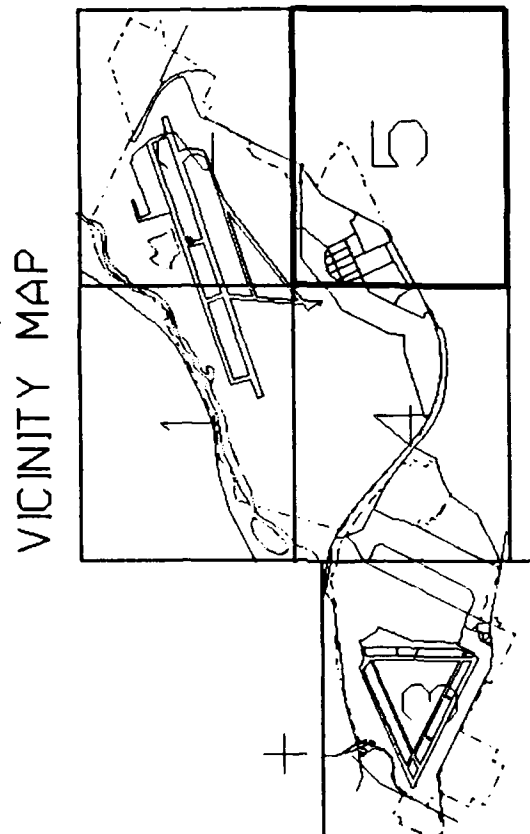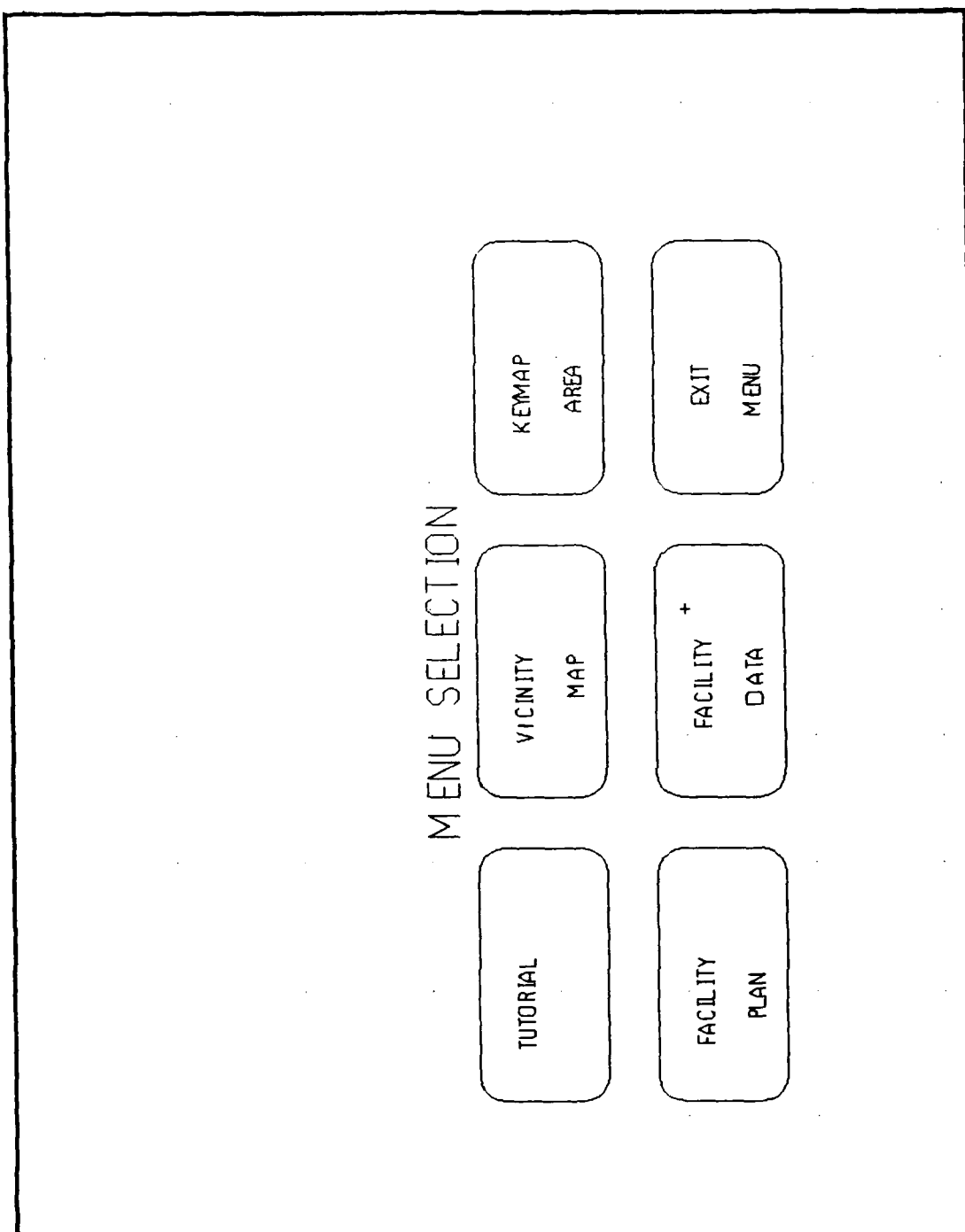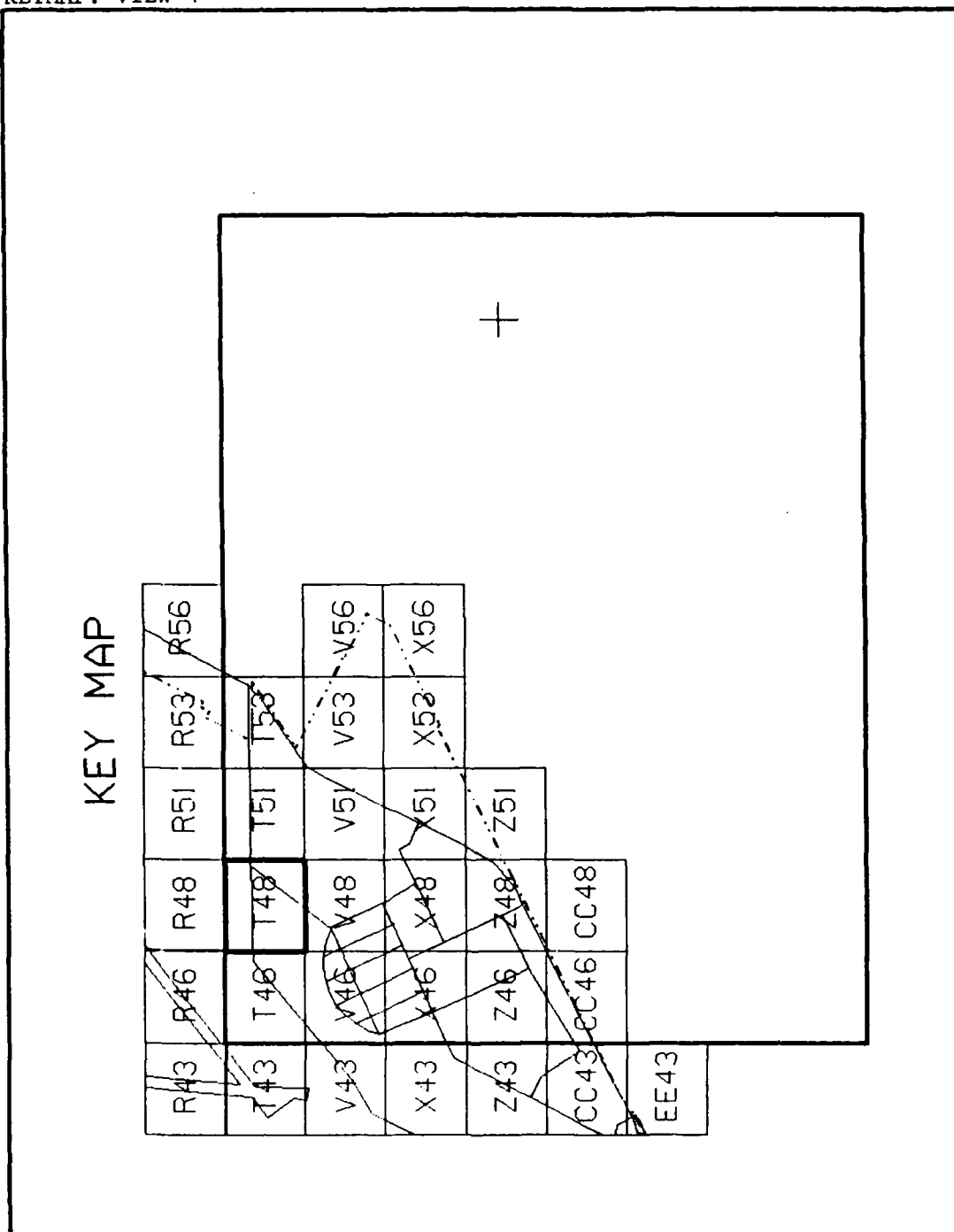
KEYMAP AREA T48: VIEW 5

VICINITY MAP AREA 5

A.5

FIRST FLOOR PLAN
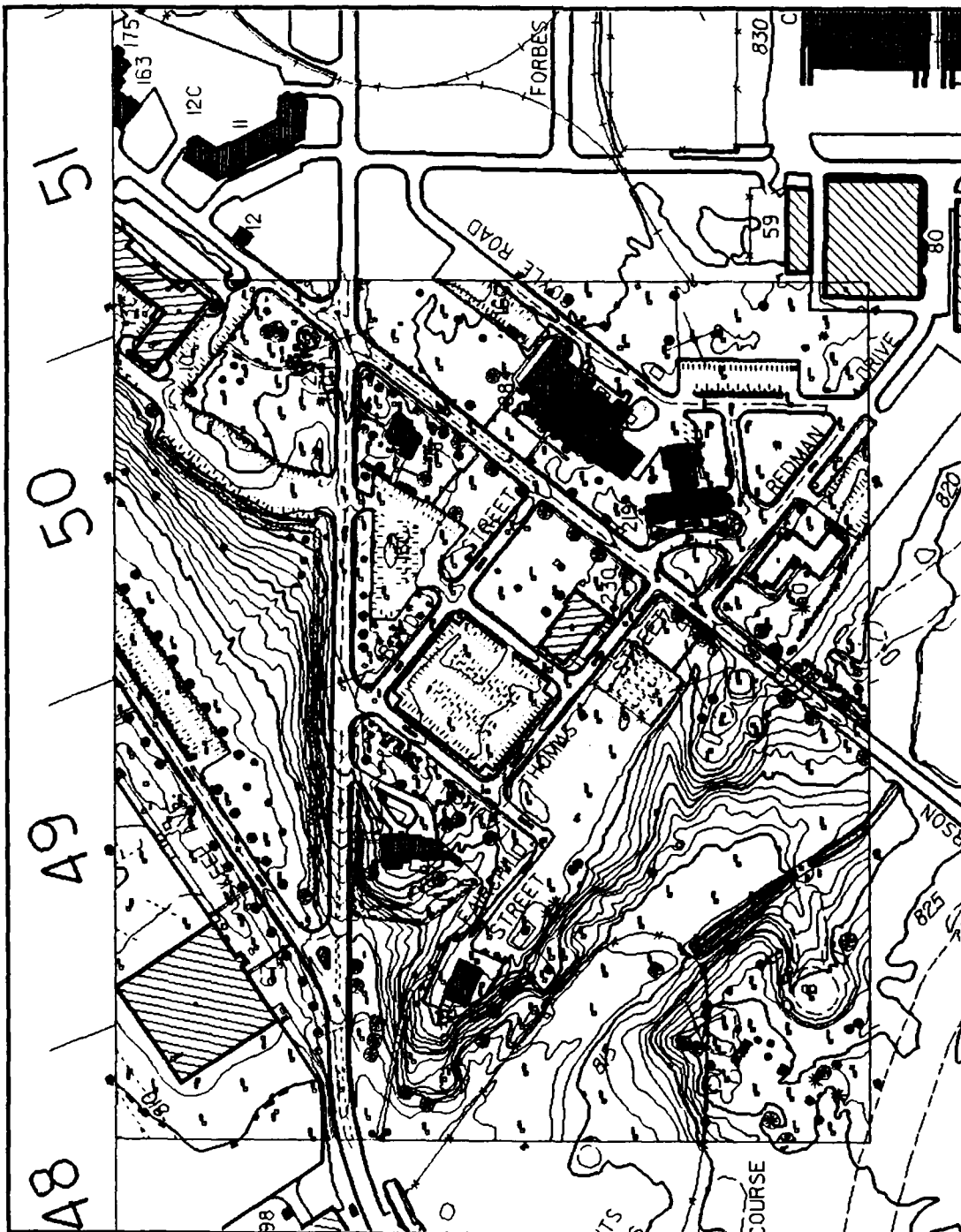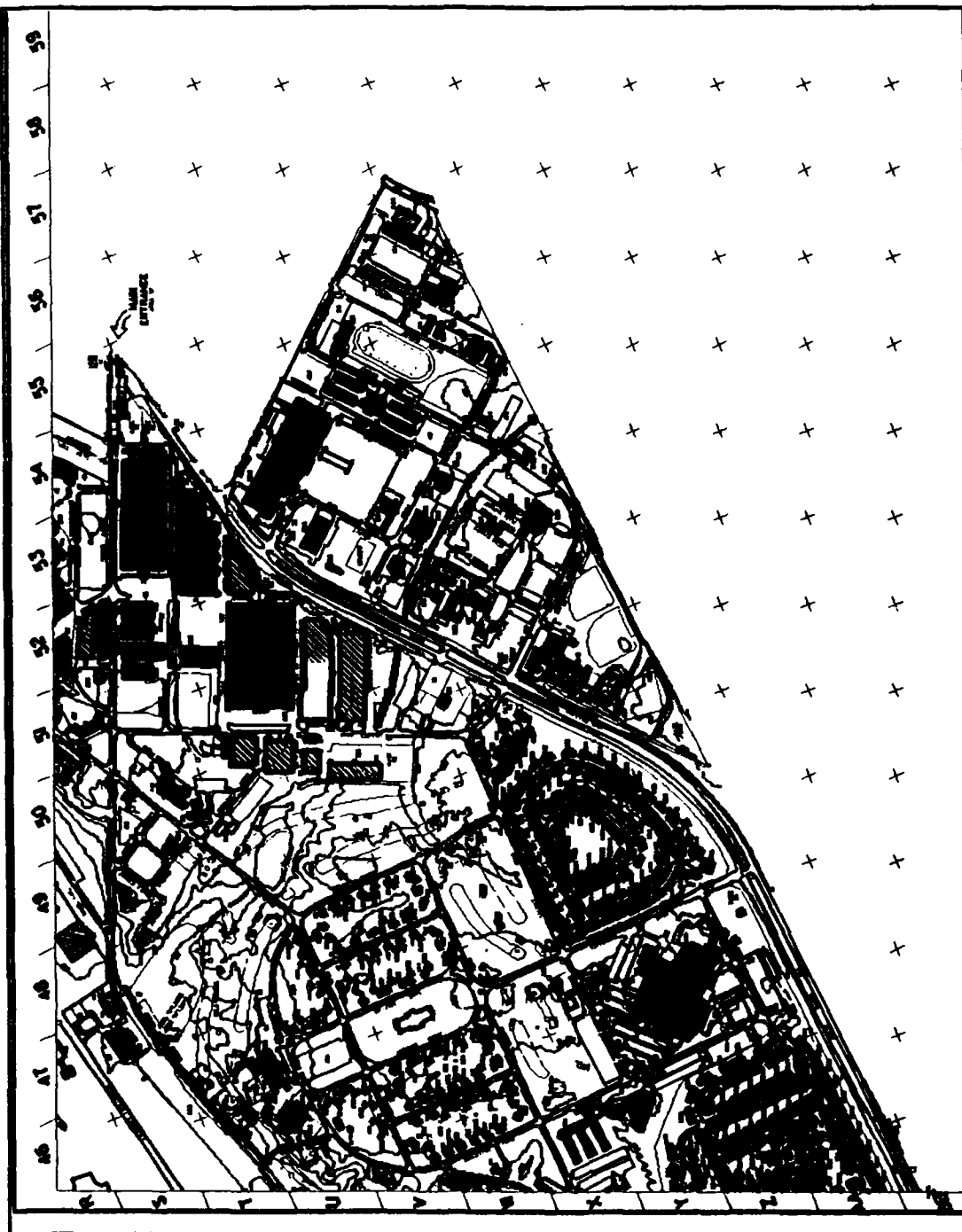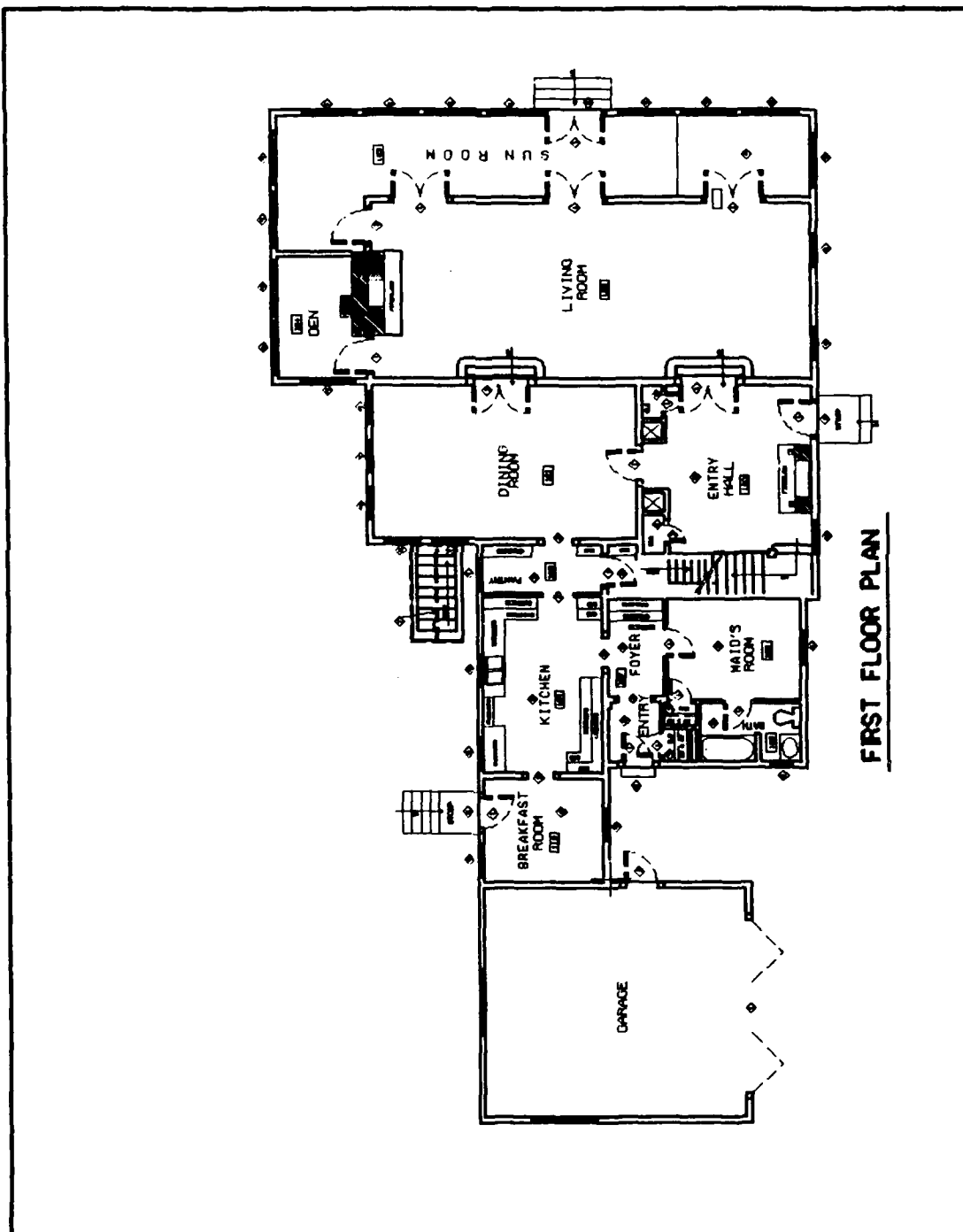
```
;                        MENU.UCM
;
; Implements  a simple screen menu. Attaches a reference
; file with the graphics of the menu. Text on the menu
; is  attached to a database record which contains the
; underlying commands. Commands may be either user
; commands or simple key ins.

    key 'noecho'
    cmd nulcmd

    key 'reference detach all'
    key 'update 3'                ; screen menu view
    key 'update 4'                ; reference file view
    key 'rf=screen,menu,ref file' ; attach reference file
    key 'menu'                    ; by named view
    key '1:1'

    set a0 = vwxdl(3) / 2         ; x center of view
    set a0 = vwxor(3) + a0
    set a1 = vwydl(3) / 2         ; y center of view
    set a1 = vwyor(3) + a1
    pnt a0,a1,0,3          ; reference file center point

start:
    msg 'cfSCREEN MENU'
    msg 'st '
    msg 'prSELECT A COMMAND FROM THE SCREEN MENU'
    get p,fndcmd,r,exituc
    go start

fndcmd:
    cmd locele

nextel:
    pnt xur,yur,,,,,@100,@1,1  ; search only for text
    tst relerr eq 0, parse     ; and text nodes on lev=1
    msg 'erCOMMAND BLOCK NOT FOUND'
    go start

parse:
    cmd locele             ; unhighlight  screen command  button
    cmd nulcmd
    set i0=16+id.cnt       ; attribute data follows here in
                           ; dgbuf()
    set i0=i0+4            ; database entity
```

B.1

```
        set entity=dgnbuf(i0)
        set i0=i0+1                 ; mslink key field (low word)
        set ucwrd(1) = dgnbuf(i0)
        set i0=i0+1                 ; mslink  key  field  (high word)
        set ucwrd(2) = dgnbuf(i0)
        set mslink = ucint(1)  ; mslink key field of attached
                               ; record
        dbread entity mslink 'ucm' 'string'
        tst relerr ne 0,error
        tst c0(1) eq 'Y', newucm       ; is this a user command ?

keyin:
        set msg = 'msKeyin: '+c1       ; issue the keyin
        msg msg
        key c1
        go start

newucm:                              ; call the user command
        set msg = 'msUcm: '+c1
        msg msg
        cls c1
        go start

error:
        cls 'dberror'            ; handle dbread / dbwrite error
                                 ; codes
        go start

exituc:
        key 'reference detach all'
        key 'update 3'          ; clear screen menu view
        key 'update 4'          ; clear  state reference file view
     cmd locele                 ; unhighlight any highlighted
                                ; elements
        cmd nulcmd
        key 'noecho'
        key 'echo'
        msg 'stSCREEN MENU EXITED'
        end




        ;                   VICMAP.UCM
        ;
        ;    Locates a 400 scale drawing in the graphic data
        ;       base and displays the graphics.

        key 'noecho'
        cmd nulcmd
        msg 'cfVICMAP'
```

```
prompt:
      msg 'st '
      msg 'cf'
      msg 'prENTER THE VICINITY MAP AREA NUMBER'
      get k,find,r,exituc

find:
      key 'swap'
      msg 'st'
      msg 'cf'
      msg 'stDISPLAYING FILE : '
      set key = 'rf='+key
      key key
      key 'ref'
      key 'ref file'
      key 'svl'
      key '35:1'
      set a0 = vwxdl(5) / 3          ; x center of view of 5
      set a0 = vwxor(5) + a0
      set al = vwydl(5) / 1.3        ; y center of view of 5
      set al = vwyor(5) + al
      pnt a0,al,,5                   ; center of view 5
      cmd nulcmd
      key 'echo'
      key 'window'
      msg 'cfWINDOW AREA'

input:
      get p,point,r,promp2

point:
      pnt
      go input

promp2:
      key 'noecho'
      cmd  nulcmd
      msg 'st '
      msg 'prENTER TO RETURN TO THE MENU'
      get k,promp3

promp3:
      key 'ref det'
      key 'ref'
      key 'update 5'
      key 'swap'
      go prompt

exituc:
      cmd nulcmd
      key 'noecho'
      key 'echo'
```

```
      msg 'stVICMAP EXITED'
      end




;                        KEYMAP.UCM
;
;      Locates a 50 scale drawing in the graphics data
;      base and displays the graphics.
;
;

      key 'noecho'
      cmd nulcmd
      msg 'cfKEYMAP'

prompt:
      cmd nulcmd
      msg 'st'
      msg 'prENTER THE VICINITY MAP AREA NUMBER'
      get k,find1,r,exituc

find1:
      set key = 'rf='+key
      key key
      key 'ref'
      key 'ref file'
      key 'svl'
      key 'l:l'
      set a0 = vwxdl(4) / 2          ; x center of view of 4
      set a0 = vwxor(4) + a0
      set al = vwydl(4) / 2          ; y center of view of 4
      set al = vwyor(4) + al
      pnt a0,al,,4                   ; center of view 4

promp2:
      msg 'st '
      msg 'prENTER KEYMAP AREA NUMBER'
      get k,find2,r,exituc

find2:
      key 'ref det'
      KEY 'ref'
      key 'swap'
      msg 'stDISPLAYING FILE : '
      set key = 'rf='+key
      key key
      key 'ref'
      key 'ref file'
```

```
        key 'sv1'
        key '180:1'
        set a0 = vwxdl(5) / 3        ;x center of view of 5
        set a0 = vwxor(5) + a0
        set al = vwydl(5) / 1.35     ;y center of view of 5
        set al = vwyor(5) + al
        pnt a0,al,,5                 ; center of view 5


promp2:
        msg 'st'
        msg 'prENTER TO RETURN TO MENU '
        get k,promp3,r,exituc

promp3:
        key 'ref det'
        key 'ref'
        key 'update 5'
        key 'swap'
        go prompt
exituc:
        cmd nulcmd
        key 'noecho'
        key 'echo'
        msg 'stKEYMAP EXITED'
        end




        ;                    PLAN.UCM
        ;
        ;    Locates a plan in the WPAFB.DBF database. If the
        ;     record has a reference file listed, it is attached
        ;     and displayed in View 5. The database record
        ;     attached is.

        key 'noecho'
        cmd nulcmd
        msg 'cfSHOW PLAN'

prompt:
        cmd nulcmd
        msg 'st '
        msg 'prENTER THE FACILITY NUMBER'
        get k,find,r,exituc
        go prompt

find:
        msg 'stLOCATING THE DATABASE'
        set  key  =  'find  fac:fclty=  '+key ; locate the record in
        key key                          ; the database
```

```
     tst relerr ne 0, notfnd
     key 'reference detach'           ; remove reference file
     key 'ref'                  ; all files use logical 'ref' tst
     relerr eq 0, update              ; successful detach
     cmd nulcmd                       ; no file found; abort command

update:
     key 'update 5'
     key 'swap'
     msg 'er '
     msg 'stReading REFERENCE FILE'
     dbread 'fac' mslink 'reffile' 'saveview' 'refscale'
     ; c0 = reference file, c1 = named view, c2 = scale
     factor tst relerr ne 0, error
     set msg = 'stDisplaying file: '+c0
     msg msg
     set key = 'rf='+c0         ; attach reference file
     key key
     key 'ref'
     key 'ref file'
     set r0 = 1                 ; strip trailing spaces from named
                               ; view.
loop:
     tst c1(r0) eq ' ', done
     tst r0 gt n1, done
     set r0 = r0 + 1           ; have we gone too far ?
     go loop

done:
     set n1 = r0 -1
     key c1                         ; send the named view
     key '3500:1'                   ; scale factor c2
     set a0 = vwxdl(5) / 3          ; x center of view of 5
     set a0 = vwxor(5) + a0
     set a1 = vwydl(5) / 1.25       ; y center of view of 5
     set a1 = vwyor(5) + a1
     pnt a0,a1,,5                   ; center of view 5
     go promp2

promp2:
     cmd nulcmd
     msg 'st '
     msg 'prRETURN TO DISPLAY DATA'
     get k,attrib,r,exituc
     go prompt

attrib:
     msg 'stREADING ATTRIBUTES'
     key 'show ae'
     cmd nulcmd

promp3:
```

```
        msg 'st'
        msg 'pr'
        msg 'prENTER TO RETURN TO THE MENU'
        get k,promp4,r,exituc

promp4:
        key 'ref det'
        key 'ref'
        key 'update 5'
        key 'swap'
        go prompt


error:
        cls 'dberror'
        go prompt

notfnd:
        msg 'erRECORD NOT LOCATED'
        go prompt

exituc:
        cmd nulcmd
        key 'noecho'
        key 'echo'
        msg 'stDISPLAY PLAN EXITED'
        end




        ;                       DATA.UCM
        ;

        key 'noecho'
        cmd nulcmd

prompt:
        cmd nulcmd
        msg 'prENTER SEARCH AREA'
        get k,find,r,exituc

find:
        key 'swap'
        set key = 'rf='+key             ; attach reference file
        key key                         ; by named view file
        key 'ref'
        key 'ref file'
        key 'svl'
        key '180:1'
        set a0 = vwxdl(5) / 3                    ; x center of view
```

```
            set a0 = vwxor(5) + a0
            set al = vwydl(5) / 1.35  ; y center of view
            set al = vwyor(5) + al
            pnt a0,al,0,5             ; reference file center point

start:
       key 'noecho'
       cmd nulcmd
       msg 'cfDATA SEARCH'
       msg 'st '
       msg 'prSelect a Facility'
       get p,fndcmd,r,exituc
       go start


fndcmd:
       cmd locele

nextel:
       pnt xur,yur,,,,,@100,@1,31      ; search only for text and
       tst relerr eq 0, parse          ; on level 1
       msg 'erCommand block not found'
       go start

parse:
       cmd locele                  ;  unhighlight  our  screen command cmd
nulcmd
       set i0=16+id.cnt      ; attribute data follows here in
       set i0=i0+4          ; database entity
       set entity=dgnbuf(i0)
       set i0=i0+1          ; mslink key field (low word)
       set ucwrd(1) = dgnbuf(i0)
       set i0=i0+1          ; mslink  key field (high word)
       set ucwrd(2) = dgnbuf(i0)
       set mslink = ucint(1) ; mslink key field of attached
                             ; record
       key 'find entity:mslink'
       key 'show ae'
       go start

exituc:
       key 'reference detach all'
       key 'update 5'        ; clear screen menu view
       key 'swap'            ; clear state reference file view
       cmd nulcmd
       key 'noecho'
       key 'echo'
       msg 'stDATA SEARCH EXITED'
       end
```

Appendix C: <u>Database Files</u>

IGSCTRL.DBF: dBASE III DATABASE SETUP

Database	wpafb.dbf	Database Alias	fac

Database   wpafb.dbf   Database Alias   fac
Report File   *   Entity Number   1
Format File   wpafb.fmt
Index Files   wpafb.msl   fclty.ndx
Index Key   Field: 10 Key: Mslink Field: 1 Key: fclty

Database   menu.dbf   Database Alias menu
Report File   menu.rpt   Entity Number   2
Format File   menu.fmt
Index Files   com.ndx   *
Index Key   Field: 2 Key: com   *

Database   *   Database Alias
Report File   *   Entity Number   3
Format File   *
Index Files   *   *
Index Key   *   *

MENU.DBF

Structure for database: C:MENU.DBF
Number of data records: 6
Date of last update: 07/19/88

Field	Field Name	Type	Width	DEC
1	MSLINK	Numeric	10	
2	COM	Character	10	
3	STRING	Character	30	
4	UCM	Logical	1	
Total			5	

Sample Data: MENU.DBF

RECORD#	MSLINK	COM	STRING	UCM
1	1	tutor	tutor.ucm	.T.
2	2	vacmap	vacmap.ucm	.T.
3	3	keymap	keymap.ucm	.T.
4	4	plan	plan.ucm	.T.
5	5	data	data.ucm	.T.
6	6	exit	exit.ucm	.T.

WPAFB.DBF

Structure for database: WPAFB.DBF
Number of data records: 576
Date of last update: 07/19/88

Field	Field Name	Type	Width	Dec
1	FCLTY	Character	5	
2	DOMORG	Character	10	
3	DOMOFC	Character	5	
4	COMMAND	Character	4	
5	DOMCATCODE	Character	6	
6	NOMEN	Character	50	
7	TOTAREA	Numeric	6	
8	VACAREA	Numeric	6	
9	VACAREA	Numeric	4	
10	MSLINK	Numeric	10	
Total			10	

Sample Data: WPAFB.DBF

Records #   FCLTY DOMORG   DOMOFC   COMMAND   DOMCATCODE
             NOMEN   TOTAREA   VACAREA   YRCONST   MSLINK

     1   10039 2750   SS   OF   750422   GOLF CLUBHOUSE/
EQUIPMENT BUILDING   202   0   49   1

     2   10050 2750   DE   OF   890187   UTILITY VAULT
                           87   0   48   2

     3   10061 2750   SS   OF   750422   GOLF CLUBHOUSE/
EQUIPMENT BUILDING   575   0   17   3

     4   10064 2750   SV   OF   740443   TRANSIENT LODGING
FACILITY APPROPRIATED   1397   0   37   4

     5   10262 AFLC   NONE OF   610284   MAJOR COMMAND
HEADQUARTERS   544402   0   42   5

     6   10263 2046   CIG   OY   131111   TELECOMMUNICATIONS
FACILITY   549   0   83   6

     7   10264 2750   DE   OF   890187   UTILITY VAULT
                         3020   0   78   7

     8   10265 2750   SP   OF   730839   TRAFFIC CHECK
  HOUSE   49   0   74   8

     9   10266 AFLC   NONE UNKN 610284   MAJOR COMMAND
HEADQUARTERS   229871   0   64   9

    10   10269 2750   DE   OF   730275   BUS SHELTER
                           71   0   83   1

C.2

Appendix D: <u>PC/VS Access Screen Menus</u>

W A N G   P R O F E S S I O N A L   S O F T W A R E
System Services Release 3.20
Main Menu

Select an Item and Proceed

                    Applications
                    Wang Local VS Connection
                    <u>Communications</u>
                    DOS Command Processor
                    Printer Support
                    Program Development
                    System Utilities
                    Other

                         SPACE BAR - Item Select
                         EXECUTE   - Proceed
                         CANCEL   - Previous Menu

W A N G   P R O F E S S I O N A L   S O F T W A R E
System Service Release 3.20
Communications Menu

Select an Item and Proceed

                    <u>PC/VS Data Exchange</u>
                    Select Communications Port Mode
                    System Utilities
                    Other

                         SPACE BAR - Item Select
                         EXECUTE   - Proceed
                         CANCEL   - Previous Menu

Wang Professional Software
P C / V S   D A T A   E X C H A N G E
REV 02.00.00 (c) Copr. Wang Laboratories, Inc. 1987

Source/Input

Documents   Data Files

PC WP Documents   PC Text File
VS WP Documents   PC Stream File
                                           VS Consecutive File
                                           VS Print File
                                           VS Indexed File

   Spreadsheets

   Sylk File
   DIF File
   PC 20/20 Data File
   VS 20/20 Data File

Please Select Option
(1) Directory (5)   (9)   (13) Communication
(2)   (6)   (10)   (14)
(3)   (7)   (11)   (15)
(4)   (8)   (12)   (16)

VS Communications
Display/Edit VS Parameter File

Wang Professional Computer
F I L E   S E R V E R   F U N C T I O N S
Version 02.00.04 (c) Copyright, Wang Laboratories, Inc.,1987

Select an Item and Proceed

File Server Attach
File Server Detach
File Server Status

CANCEL - Exit
EXECUTE - Proceed

Wang Professional Computer
F I L E   S E R V E R   F U N C T I O N S
V Version 02.00.04 (c) Copyright, Wang Laboratories, Inc.,1987

Select an Item and Proceed

File Server Attach
File Server Detach
File Server Status

CANCEL - Exit
EXECUTE - Proceed

File Server Attach Successful		
Local Comm. Card	:	Present
File Server Software	:	Present
Local Comm. Card in Use by	:	File Server
File Server Attached to	:	VS
ID of the User Logged on to VS	:	STS

Source/Input

Documents   Data Files

PC WP Document   PC Text File
VS WP Document   PC Stream File
                                             VS Consecutive
                                             VS Print File
                                             VS Indexed File

        Spreadsheets

        Sylk File
        DIF File
        PC 20/20 Data File
        VS 20/20 Data File

Please Select Option
(1) Directory (5)   (9)   (13) Communication
(2)   (6)   (10)   (14)
(3)   (7)   (11)   (15)
(4)   (8)   (12)   (16)

Wang Professional Software
P C / V S   D A T A   E X C H A N G E
REV 02.00.00 (c) Copr. Wang Laboratories, Inc.,1987

Destination/Output

Documents   Data Files

PC WP Document   PC Text File
VS WP Document   PC Stream File
                                             VS Consecutive File
                                             VS Print File
                                             VS Indexed File

        Spreadsheets

        Sylk File
        DIF File
        PC 20/20 Data File
        VS 20/20 Data File

Please Select Option
(1) Directory (5)   (9)   (13) Communication
(2)   (6)   (10)   (14)
(3)   (7)   (11)   (15)
(4)   (8)   (12)   (16)
Source/Input: VS Consecutive File

PC/VS DATA EXCHANGE: VS Consecutive File to PC Stream File

Source: VS   Consecutive File   Range
                                                    From   Thru

Pathname: DAT002:CADD.WPAFB5   Row 1   Column 1
            volume:library.file

Character Set Conversion ?   Yes ~ No

Destination: PC Stream File

Pathname: C:/DGN/WPAFB5.DGN   Column 1
            drive: /directory/file.ext

Please enter Information
(1) Directory (5)   (9)   (13)
(2)   (6)   (10)   (14) View Data
(3)   (7)   (11)   (15)
(4)   (8)   (12)   (16)

DATA EXCHANGE: VS Consecutive File to PC Stream File

Source: VS Consecutive File   Range
                                                 From   Range
Pathname: DAT002:CADD.WPAFB5   Row 1
            volume:library.file   Column 1

Character Set Conversion ? Yes ~ No

Destination: PC Stream File

Pathname: C:/CADDDATA/WPAFB5.DGN   Column 1
            drive:/directory/file.ext

Please Enter Information
(1) Directory (5)   (9)   (13)
(2)   (6)   (10)   (14) View Data
(3)   (7)   (11)   (15)
(4)   (8)   (12)   (16)
C:/CADDDATA/WAFB5.DGN created, number of bytes 131440

Wang Professional Computer
F I L E   S E R V E R   F U N C T I O N S
Version 02.00.04 (c) Copyright, Wang Lab., Inc., 1987

Select an Item and Proceed

                    File Server Attach
                    File Server Detach
                    File Server Status

                              CANCEL - Exit
                              EXECUTE - Proceed

File Server Detach Sucessful
Local comm. Card	:	Present
File Server Software	:	Present
Local Comm. Card in Use by	:	None

Appendix E: <u>VMS and Unix Command Summary</u>

To load all the files on a backup tape to the Intergraph 200 hard disk:

$ BAC MSAO:*.*.* ZFA2:(02020)*.*.*

To copy the file WPAFB5.400;1 from the Intergraph 200 hard disk to a magnetic tape for transfer to the Wang VS100 using the COPY utility:

```
$ MOUNT/FOREIGN/NOHDR3 MSAQ:
% MOUNT-I-MOUNTED, mounted on _MSA0
$ COPY ZFA2:(02020)WPAFB5.400;1
_To: MSA0:IGS
$ DISMOUNT MSA0:
```

To upload file WPAFB5.400;1 from the Intergraph 200 hard disk to the Interview 32C workstation's hard disk:

```
# FMU          ;Log on to the Intergraph 200's File Management
          Utility

FMU> RECIEVE WPAFB5.400;1 WPAFB5.DGN   ;Recieve  the file and
                                        rename it.
/ETC/FORMAT;Format the floppy diskette
/ETC/MKFS/ /DEV/DSK/FLOPPY 2400   ; Make a file system
# MF          ;Mount the floppy
CD /MNT       ;change to the MNT directory
CP /WPAFB5.DGN /MNT/WPAFB5.DGN  ;copy the file to the floppy
CD /MNT       ;change the directory
UF            ;unload floppy
```

UNIX to DOS Utility (UTD)

UTD -p /USR/IP32/MSTATION/WPAFB5.DGN a:WPAFB5.DGN

DOS to UNIX Utility (DTU)

DTU -p a:WPAFB5.DGN /USR/IP32/MSTATION/WPAFB5.DGN

```
To copy from floppy to harddrive:
SU
# MF
CP /USR/IP32/MSTATION/WPAFB5.DGN /MNT/WPAFB5.DGN
CP /MNT/WPAFB5.DGN /USR/IP32/MSTATION/WPAFB5.DGN
# UF
```

```
*******************************************************************
*                                                                 *
*  Wang Office - Run Program Screen                               *
*                                                                 *
*                                                                 *
*                                       Program  =  TAPECOPY      *
*                                                                 *
*     Supply the Name of the PROGRAM                              *
*     (or PROCEDURE)  to be executed                              *
*     and Press (ENTER):                Library  =  @SYSTEM@      *
*                                       Volume   =  SYS001        *
*  OPTIONS -                                                      *
*                                                                 *
*     Designate a user library which                              *
*     includes programs (or procedures)                           *
*     to be used during this run:                                 *
*                                                                 *
*                Press (PF16) to RETURN to the Menu               *
*                                                                 *
*******************************************************************
```

```
*********************************************************************
*                                                                   *
*                                                                   *
*             INFORMATION REQUIRED BY PROCEDURE OFFICE               *
*                       TO DEFINE INPUT                              *
*                   ACTIVE PROGRAM IS TAPECOPY                       *
*                                                                   *
*   Wang VS Tapecopy Program Version 7.19.19                        *
*                                                                   *
*   Copyright, Wang Laboratories, Inc. 1985                         *
*   Please identify the input file:                                 *
*     FILE    = ********   LIBRARY = ********   VOLUME  = IGS        *
*     DEVICE  = TAPE****                                             *
*     CONVERT = N*     N=No Conversion, E=EBCDIC to ASCII, A=ASCII to EBCDIC  *
*                      BA=BCD Format A to ASCII, AB=ASCII to BCD Format A     *
*                      HA=BCD Format H to ASCII, AH=ASCII to BCD Format H     *
*     MULTYPE  = N     Y=Multiple record types, N=Single record type         *
*                                                                   *
*   If input is from a tape file, please specify:                   *
*     FSEQ    = ***1  File sequence number                          *
*     LABEL   = NL    AL=ANSI Label, IL=IBM Label, NL=No Label       *
*   IBM DOS Tape:                                                    *
*     Does the file contain an HDR2 label?  HEADER2  = NO   (YES or NO)  *
*                                                                   *
*             Press PF16 to terminate the TAPECOPY program.          *
*                                                                   *
*                                                                   *
*********************************************************************
```

F.2

```
***************************************************************

***  MESSAGE 0002 BY TPCOPY

           INFORMATION REQUIRED BY PROCEDURE OFFICE
                     TO DEFINE TAPEFILE
                 ACTIVE PROGRAM IS TAPECOPY

   Please describe the tape record  format


        RECFORM    = F         F=fixed, V=Variable (Wang format),
                               I=Variable (IBM format), U=Undefined

   LARGEST RECSIZE = 512******  (4-2048)

        BLOCKED    = Y         (Y=Blocked,  N=Not Blocked)

   LARGEST BLKSIZE = 2048*****  (18-32760)

        COMPRESS   = N         (Y=Yes, N=No)

***************************************************************
```

```
*********************************************************************************
*                                                                              *
*   *** MESSAGE 0001 BY TPCOPY                                                  *
*                                                                              *
*           INFORMATION REQUIRED BY PROCEDURE OFFICE                           *
*                     TO DEFINE OUTPUT                                         *
*                 ACTIVE PROGRAM IS TAPECOPY                                   *
*                                                                              *
*   Wang VS Tapecopy Program Version 7.19.19                                   *
*                                                                              *
*   Please identify the output file:                                          *
*                                                                              *
*      FILE    = WPAFB5    LIBRARY = CADD****   VOLUME  = DAT002               *
*                                                                              *
*      DEVICE  = DISK****                                                       *
*                                                                              *
*   If output is to a tape file, please specify:                              *
*                                                                              *
*      FSEQ    = ***1  File sequence number                                   *
*                                                                              *
*      LABEL   = NL   AL=ANSI Label, IL=IBM Label, NL=No Label                 *
*                                                                              *
*                                                                              *
*********************************************************************************
```

F.4

```
*********************************************************************************
*                                                                              *
*  *** MESSAGE 0301 BY TPCOPY                                                   *
*                                                                              *
*         INFORMATION REQUIRED BY PROCEDURE OFFICE                             *
*                    TO DEFINE DISKFILE                                         *
*                 ACTIVE PROGRAM IS TAPECOPY                                    *
*                                                                              *
*  Please supply number of records and modify output file attributes as necessary:  *
*                                                                              *
*    NRECS    = 2620****                                                        *
*    FILEORG  = C      Options  = C-Consecutive, I-Indexed, X=Program, P-Print  *
*    RECFORM  = F      Options  = F-Fixed Length, V-Variable Length             *
*    COMPRESS = N      Options  = Y-Yes, N-No                                   *
*    FILECLAS = $      RETAIN   = *** Days                                      *
*                                                                              *
*  For indexed files, please specify:                                          *
*                                                                              *
*    KEYLEN   = ***    KEYPOS   = ***** From 1                                  *
*    IPACK    = 100 %  (Packing density for index blocks)                      *
*    DPACK    = 100 %  (Packing density for data blocks)                       *
*                                                                              *
*    (ENTER) To create the output file using the current Access List           *
*     (PF9)  To modify the current Access List                                 *
*    (PF10)  To create the output file with the user'sdefault Access List      *
*    (PF12)  To create the output file without an Access List                  *
*                                                                              *
*********************************************************************************
```

F.5

```
*******************************************************************
*                                                                 *
*   *** MESSAGE 0001 BY TPCOPY                                     *
*                                                                 *
*         INFORMATION REQUIRED BY PROCEDURE OFFICE                *
*                     TO DEFINE EOJ                               *
*                ACTIVE PROGRAM IS TAPECOPY                       *
*                                                                 *
*   Wang VS Tapecopy Program Version 7.19.19                     *
*                                                                 *
*                                                                 *
*   File WPAFB5   in CADD     on DAT002 created with    2620 records. *
*                                                                 *
*                                                                 *
*   Press PF1 to rerun the Tapecopy program or PF16 to end the job. *
*                                                                 *
*******************************************************************
```

Appendix G: <u>Prototype System Cost</u>

PROTOTYPE HARDWARE
(as of 1 Mar 88)

<u>DESCRIPTION</u>	<u>PRODUCT NUMBER</u>	<u>EST. COST</u>

Basic Workstation (80386 based CPU):

1. Wang 380-3   PC 380-3 $5,267.00 (GSA)

Comes with:

    68 Mb Hard Drive

    80386 CPU (16 MHz clock speed, 640K RAM)

    1.2Mb Diskette Drive

    2.5Mb Memory

    1 Serial Pcrt

    1 Parallel Port

    EGA Color Graphics Card

    Operating System Software WPS-MSDOS-PC2-9   *

    Country Kit   PC2-CK-US   *

Enhancements to Workstation:

2. Additional Serial Port   COM-0001-PC2   # 212.00 (GSA)

3. Math Coprocessor   MTH-0287-PC3   # 535.00 (GSA)

(Essential for AutoCAD and Microstation)

4. 360Kb Flppy Drive   DSK-0360-PC2   # 155.00

5. Wang Communications Board VS-WLOC-PC2   # 612.00 (GSA)

(Allows Communication between VS and PC)

6. Wang Color Monitor   MON-1450-PC2   # 684.00

7. Mouse   725-3461 $ 116.00 (GSA)

8. Wang Serial Port Adapter   725-3462 $ 19.00 (GSA)

(Note: Add approximately $200.00 to have Wang add the

enhancements to the 380 prior to shipment)

Local Mass Storage Device

9. IOMEGA Bernoulli Cartridge Storage $ 2,000.00

    (dual 20 Mb 5-1/4", cartridge $100.00 ea.)

Digitizing Tablet System

10. GTCO 11" x 11"   DP5A-1111A $ 767.15

     Tablet cursor, 16 button DP5-16C4 $ 96.00

11. GTCO 36" x 48" Tablet Sys.DP5A-3648A $3,800.00

     (for data entry from E and smaller size drawings)

     Tablet Pedestal   ISIS-3648L $ 795.00

Pen Plotter System

12. Hewlett-Packard   7596A $9,044.00 (GSA)

 Draftmaster II

Page Printer for 11" x 17" working copies of drawings

13. Wang Laser Printer   LDP8-DSK $2,400.00 (GSA)

     with Graphics Memory   725-3708 add $ 812.00

Graphics Display Generator with AutoCAD Driver

14. Immagraph High Resolution Color Graphics Processor

    (1024 x 1024 non-interlaced res.

                              IP1010-8-S19 $3,500.00

Color Monitor for dual screen operation

15. Sony High Resolution Color Graphics Monitor

    (1024 x 1024 non-interlaced res. compatible

    with item 14 above).   GDM 1950 $2,500.00

PROTOTYPE SOFTWARE

DESCRIPTION	PRODUCT NUMBER	EST. COST
GRAPHIC SOFTWARE		
AUTOCAD (Latest Version) with Drafting		
Extensions 1, 2, & 3		$2,800.00
and		
MICROSTATION (Latest Version)		$3000.00
DATA BASE MANAGEMENT SOFTWARE		
dBase III Plus (for PC)		$ 350.00
WANG COMMUNICATIONS SUPPORT SOFTWARE		
VIRTUAL DISK PC ACCESS TO	VDISK-PC2-9	$ 53.00
WANG VS (GSA)		

DATA EXCHANGE VS ACCESS UTILITY WPS-ISDE-PC-9   * 175.00 (GSA)

SYSTEM SER. MENU/SHELL & ULT.   WPS-SYSER-PC2-9 * 53.00
EDITOR (GSA)

MULTISTATION FOR MULTI WINDOWS   WPS-MULST-PC2-9 * 105.00
(GSA)

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ADA201488

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
Unclassified	

2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
AFIT/GEM/DEE/88S-15	

6a. NAME OF PERFORMING ORGANIZATION	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
School of Systems and Logistics	AFIT/LSM	

6c. ADDRESS (City, State, and ZIP Code)	7b. ADDRESS (City, State, and ZIP Code)
Air Force Institute of Technology Wright-Patterson AFB, Ohio 45433-6583	

8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS			
	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)

See Box 19

12. PERSONAL AUTHOR(S)
Alfred C Scharff, Captain, USAF

13a. TYPE OF REPORT	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) 1988 September	15. PAGE COUNT 106

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	
09	02		Computer Aided Design and Drafting (CADD)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

TITLE: TECHNOLOGY ACCESSMENT AND IMPLEMENTATION OF AN
INTEGRATED GRAPHICS SYSTEM FOR U.S. AIR FORCE
BASE LEVEL CIVIL ENGINEERING

Thesis Advisor: W. David Alley, Captain, USAF
Instructor of Architecture

Approved for public release IAW AFR 190-1.

WILLIAM A. MAUER   17 Oct 88
Associate Dean
School of Systems and Logistics
Air Force Institute of Technology (AU)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL W. David Alley, Captain, USAF	22b. TELEPHONE (Include Area Code) 513-255-4557 — 22c. OFFICE SYMBOL AFIT/DEM

DD Form 1473, JUN 86   Previous editions are obsolete.   SECURITY CLASSIFICATION OF THIS PAGE

Air Force Civil Engineering, for most of this decade, has been engaged in validating the applicability of CADD and other graphic applications for its use. The Air Force Engineering and Services Center Information Systems Directorate (AFESC/SI) has conducted system development and limited prototype testing through a contract with Oak Ridge National Laboratory (ORNL).

This thesis has made three basic determinations. First, the literature review served to validate ORNL's conclusion that microcomputers still provide the highest performance-to-cost ratio. Because technology is changing so rapidly, this needs to be continually revalidated.

Secondly, this thesis answered some of the basic technical questions about hardware-software and multi-vendor compatibility and data interchange that needed to be answered before AFESC/SI could proceed with IGS procurement.

Finally, this thesis demonstrated the ESIMS concept of IGS which goes beyond automating drafting and design by using such features as a database interface and macro programming language to provide a flexible and multi-functional graphic tool.